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REPAIR, EVALUATION, MAINTENANCE, AND REHABILITATION RESEARCH PROGRAM

TECHNICAL REPORT REMR-CO-3

CASE HISTORIES OF CORPS BREAKWATER AND JETTY STRUCTURES

Report 6

NORTH PACIFIC DIVISION

by

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GT	Geotechnical	EI	Environmental Impacts
HY	Hydraulics	OM	Operations Management
CO	Coastal		

COVER PHOTOS:

TOP — Concrete breakwater at Depoe Bay, Oregon (1969).

BOTTOM — Rubble-mound jetties at Tillamook, Oregon (1979).

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This report is sixth in a series of case histories of US Army Corps of Engineers (Corps) breakwater and jetty structures at nine Corps divisions. Chronological histories are presented for 14 breakwater and jetty projects located within the US Army Engineer Division, North Pacific (NPD), which includes the Portland, Seattle, and Alaska Districts. The projects currently include 68 breakwaters and 35 jetties. Nearly all of the structures are of rubble-mound construction, although steel pilings, steel sheetpilings, timber pilings, and concrete have also been used. Localized damage from wave attack and scour near the heads of the structures appears to be the major cause of structural deterioration.

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PREFACE

This report was prepared as part of the Coastal Problem Area of the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Research Program. Work was carried out jointly under Work Unit 32278, "Rehabilitation of Rubble-Mound Structure Toes," of the REMR program and Work Unit 31269, "Stability of Breakwaters," of the Civil Works Coastal Area Program. For the REMR program, Coastal Problem Area Monitor is Mr. John H. Lockhart, Jr., Office, Chief of Engineers (OCE) US Army Corps of Engineers (Corps). REMR Program Manager is Mr. William F. McCleese of the US Army Engineer Waterways Experiment Station's (WES's) Structures Laboratory, and Coastal Problem Area Leader is Mr. D. D. Davidson of WES's Coastal Engineering Research Center (CERC). Messrs. John G. Housley and Lockhart, OCE, are Technical Monitors of the Civil Works Coastal Area Program.

This report is sixth in a series of case histories of Corps breakwaters and jetty structures at nine Corps divisions. The case histories were written from information obtained from several sources (where available) which included inspection reports, conferences, telephone conversations, project plans and specifications, project files and correspondence, design memoranda, literature reviews, model studies, surveys (bathymetric and topographic), survey reports, annual reports to the Chief of Engineers, House and Senate documents, and general and aerial photography. Unless otherwise noted, any changes to the prototype structures subsequent to March 1985 are not included.

This work was conducted at WES during the period August 1986 to June 1987 under general direction of Dr. James R. Houston and Mr. Charles C. Calhoun, Jr., Chief and Assistant Chief, CERC, respectively; and under direct supervision of Mr. C. Eugene Chatham, Jr., Chief, Wave Dynamics Division, and Mr. D. D. Davidson, Chief, Wave Research Branch (CW-R). This report was prepared by Mr. Donald L. Ward, Hydraulic Engineer, CW-R, and edited by Ms. Shirley A. J. Hanshaw, Information Products Division, Information Technology Laboratory, WES.

COL Dwayne G. Lee, EN, was Commander and Director of WES during report publication. Dr. Robert W. Whalin was Technical Director.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
miles (US statute)	1.609347	kilometres
pounds (force)	4.448222	newtons
square feet	0.09290304	square metres
square miles	2.589998	square kilometres
tons (2,000 lb force)	8806.443353	newtons
cubic yards	0.7646	cubic metres
acres	4046.873	square metres

CASE HISTORIES OF CORPS BREAKWATER AND JETTY STRUCTURES

NORTH PACIFIC DIVISION

PART I: INTRODUCTION

Background

1. The US Army Corps of Engineers (Corps) is responsible for a wide variety of coastal structures located on the Atlantic, Pacific, and gulf coasts, the Great Lakes, Hawaiian Islands, other islands, and inland waterways. Coastal improvements such as jetties or breakwaters are frequently required to provide a safe harbor or navigation. These structures are continuously subjected to wave and current forces and are usually constructed on top of movable-bed materials. Under these conditions, structural deterioration may occur to the point where maintenance, repair, or rehabilitation is required for the structure to continue to meet the needs of the project. Some of the projects have been maintained for over 150 years. Methods of repair and construction have varied significantly during this time, due principally to a better understanding of coastal processes, availability of construction materials, regional construction practices, and economic considerations.

Purpose

2. The purpose of this report is to lend insight into the scope, magnitude, and history of coastal breakwaters and jetties under Corps jurisdiction; determine their maintenance and repair history; determine their methods of construction; and make this information available to Corps personnel. To accomplish these objectives, case histories of Corps breakwater and jetty structures have been developed to quantify past and present problem areas, to take steps to rectify these problems, and to subsequently evaluate remedial measures. General design guidance can be obtained from those solutions that have been most successful. Information in this report should be of particular value to Corps personnel in the US Army Engineer Division, North Pacific (NPD), and its coastal districts and possibly to non-Corps personnel.

PART II: SUMMARY OF CORPS BREAKWATER AND JETTY PROJECTS IN NPD

3. NPD presently maintains 68 breakwaters and 35 jetties located in 48 of their coastal projects. Thirty-eight breakwaters and 5 jetties are located in 20 projects in US Army Engineer District, Alaska (NPA); 9 breakwaters and 22 jetties are located in 12 projects in US Army Engineer District, Portland (NPP); and 21 breakwaters and 8 jetties are located in 16 projects in US Army Engineer District, Seattle (NPS).

4. Nearly all of the breakwaters and jetties are of rubble-mound construction, although steel pilings, steel sheetpilings, timber pilings (with or without planks), and concrete have also been used. Early structures were built primarily by dumping stone from railroad cars on a tramway constructed above the jetty or breakwater. Where the in situ material provided an insufficient foundation, structures were constructed on blankets of brush or gravel. Otherwise, structures were built directly on the existing bottom material.

5. New construction, repair, and rehabilitation work carried out on rubble-mound structures in NPS and NPP since 1961 have used placed-stone construction techniques. Due to quality control, random armor stone placement is specified for NPA structures, but use of placed-stone construction is encouraged.

6. Most of the jetty repair work is for wave-induced localized damage on the sea side of the jetty trunks. The damage consists primarily of downslope slumping of the primary armor stone as a result of both individual armor stone displacement and toe damage that allow slippage of the outer armor layers. Both NPA and NPP have constructed sacrificial toe berms of core-size material to provide added toe stability, trip incident waves to reduce runup and overtopping, and protect against scour and undermining.

7. Most of the jetty rehabilitation work consists of rebuilding jetty heads that have been lost due to scour and undermining combined with storm wave-induced armor stone displacement. Typical jetty head rehabilitation includes filling scour holes and forming a bedding foundation with minus 400-lb material then reconstructing the head using only class "A" stone.

8. Concrete armor units are not used by the division. Repair work has generally consisted of placement of additional stone, frequently of a larger size. Many of the structures have been raised and/or extended.

9. Figure 1 shows locations of the projects in NPA. The projects consist mainly of harbors protected by breakwaters and are unique among the districts in the division in three ways. First, while the harbors in southeastern Alaska were economically justified for their support of the commercial and sport fishing fleets, the harbors in southwestern Alaska have the additional justification of a scarcity of safe harbors of refuge. Second, NPA has the only harbors in the division where ice is a problem. Valdez Harbor is generally considered the northernmost ice-free port in Alaska.

10. The third unique problem of NPA was a major earthquake in 1964 which destroyed or damaged several Corps projects. Cordova Harbor was uplifted 6.4 ft*; Kodiak Harbor subsided 5 ft; Seldovia Harbor subsided 3.8 ft; and the harbors at Homer, Seward, and Valdez were completely destroyed. The harbors at Kodiak and Seldovia were rebuilt; Cordova Harbor was rebuilt and expanded; and the harbors at Homer, Seward, and Valdez were all relocated, expanded, and rebuilt. In addition, the town and harbor of Port Lions were established when the government relocated the inhabitants of the town of Afognak, which was destroyed by the earthquake.

11. The five jetties maintained by NPA are small, with the largest, 530 ft in length, protecting Aurora Harbor at Juneau. The other projects consist of a pair of jetties at Nome Harbor maintaining a channel at the mouth of the Snake River and a pair of jetties at Ninilchik Harbor maintaining a channel at the mouth of the Ninilchik River.

12. Figure 2 shows locations of projects in NPD. The projects consist primarily of jetties to stabilize channels at the mouths of rivers to provide safe navigation. Jetty pairs are located at the mouths of seven rivers, and three jetty systems are located at the mouths of three rivers. The jetties range in length from 850 ft at the mouth of the Chetco River to nearly 7 miles long at the mouth of the Columbia River. They have design waves up to 22 ft, and some date back to the late 1800's.

13. NPP maintains breakwaters at four harbors located in bays upstream from the mouths of three rivers and at two harbors located on the coast.

14. Figure 3 shows locations of projects in NPS. The projects consist mainly of harbors and small-boat basins protected by breakwaters.

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

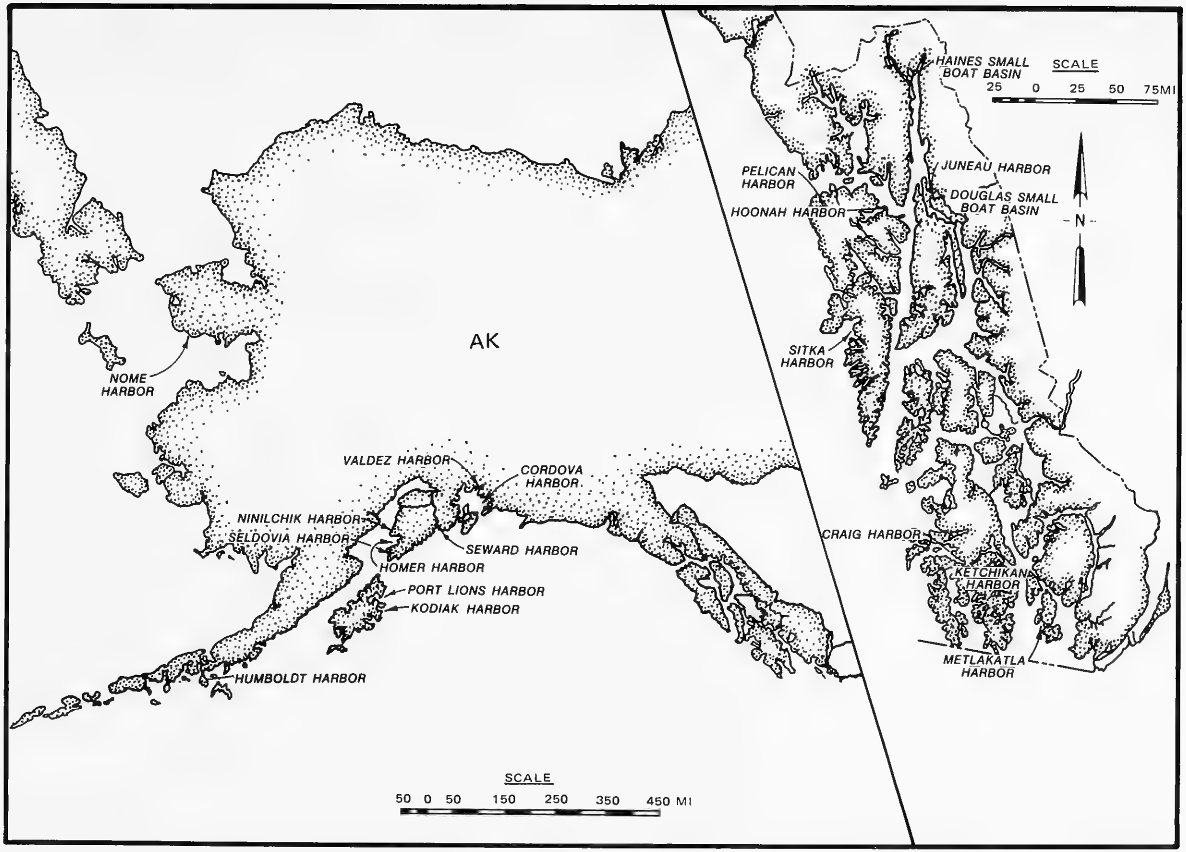

Figure 1. Locations of NPA's jetty and breakwater projects

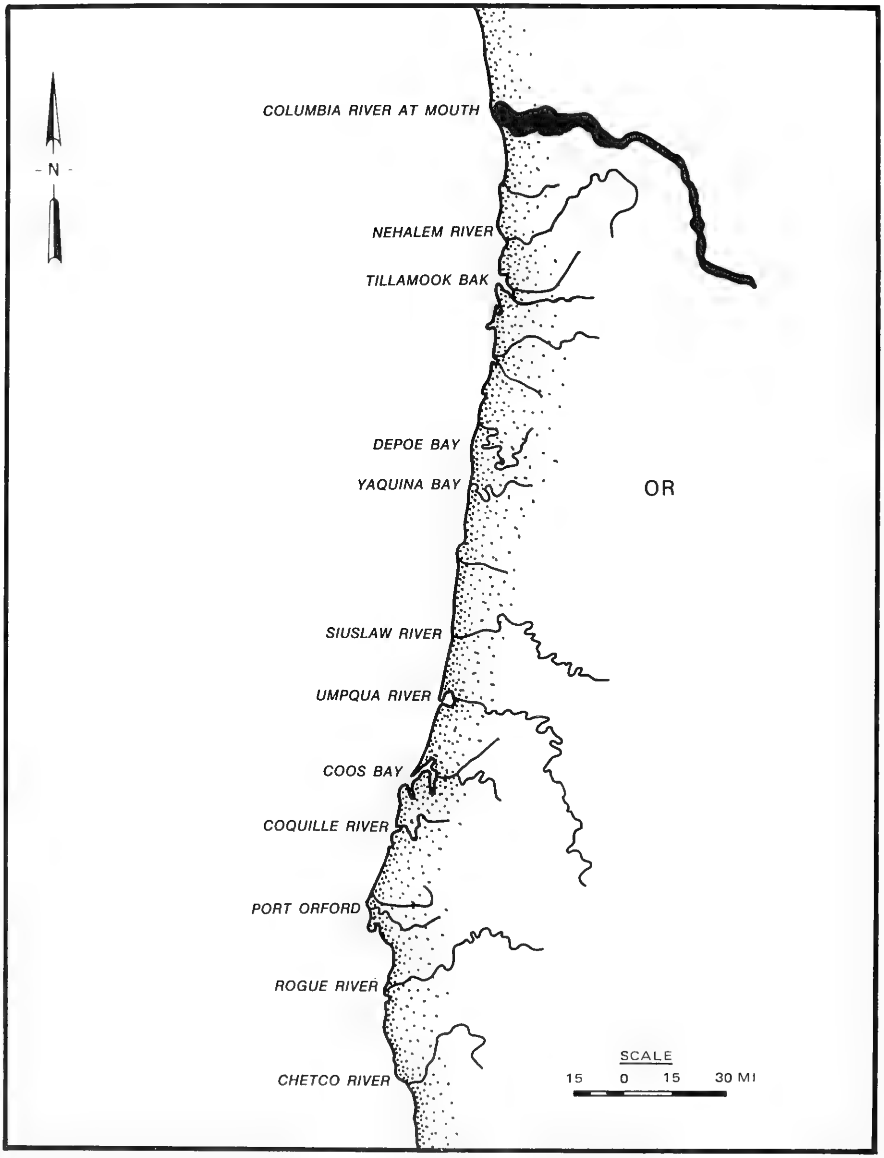

Figure 2. Locations of NPP's jetty and breakwater projects

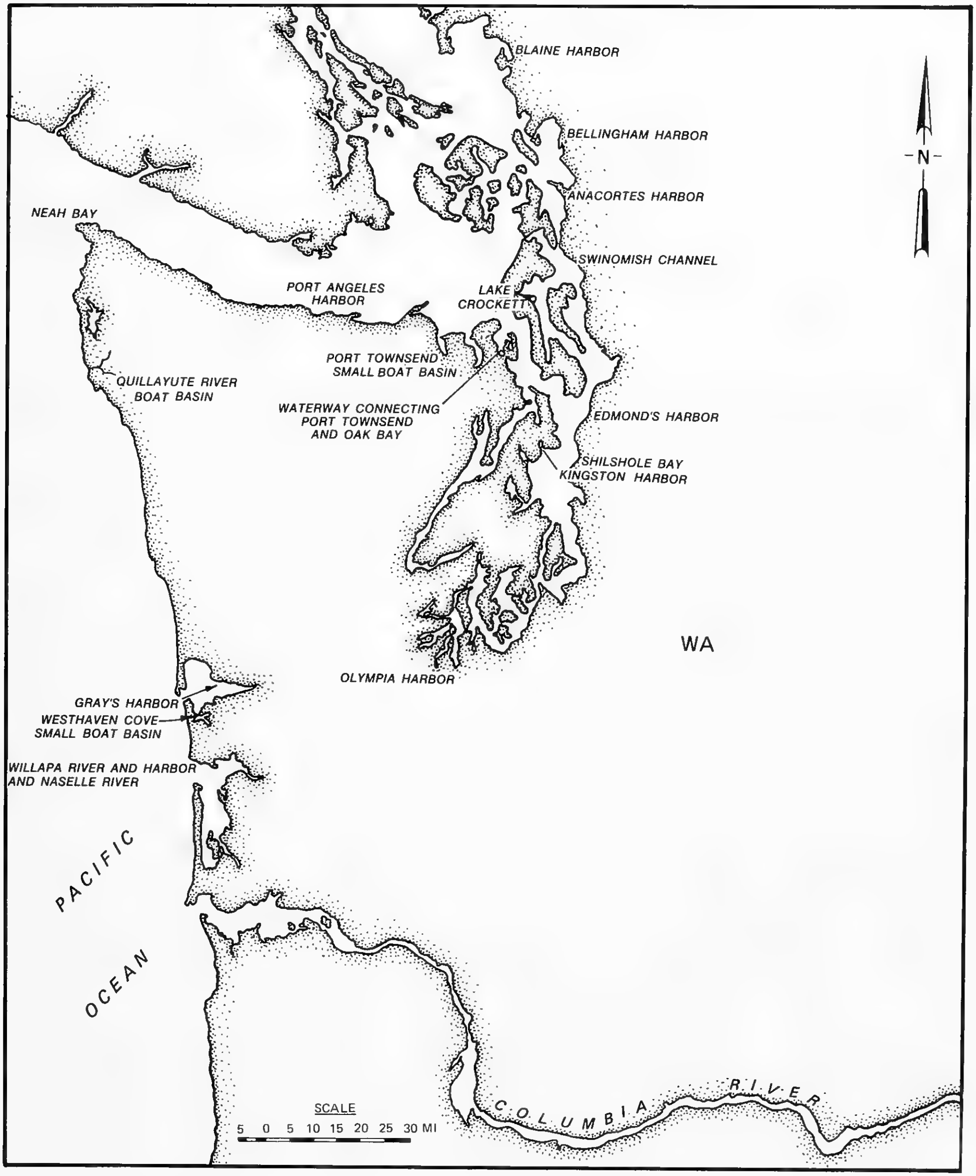

Figure 3. Locations of NPS's jetty and breakwater projects

The district maintains thirteen harbors protected by one or more breakwaters, ranging in length up to 8,000 ft.

15. Brief descriptions of the projects that include jetties or breakwaters are given in Part III, while more complete case histories of the structures are included in Tables 1-49. Pertinent summary information on each project is presented in the following listing. The projects are listed alphabetically by district.

Table No.	Project Name	Project Type	Material	Length ft	Initial Construction	Improvements
			Alaska District			
1	Cordova	B(3)	S	1,902	1983	N
			S	183	1966	N
			S,B	1,100	1938	REP,REIN
2	Craig Harbor	B(2)	S	160	1981	N
			S	300	1981	N
3	Douglas Small-Boat Basin	B(1)	S	105	1962	N
4	Haines Small-Boat Basin	B(1)	S	905	1976	N
5	Homer Harbor	B(2)	S	**	1985	N
			S	238	1965	N
		*	S	1,018	1965	N(REM)
		*	S	1,260	1962	REP
6	Hoonah Harbor	B(3)	S	800	1979	N
			S	1,507	1979	N
			S	140	1979	N
7	Humboldt Harbor	B(2)	S	1,025	1975	N
			S	740	1975	N
8	Juneau Harbor					
	Harris Basin	B(2)	S	430	1938	N
			S	1,540	1938	REP
	Aurora Basin	J(1)	S	530	1962	N
		B(1)	S,SP	1,150	1963	REP

(Continued)

KEY: Project Type: B-breakwater; J-jetty. (Number in parentheses indicates the quantity of that type of structure.) Material: S-stone; SP-steel piling; SS-steel sheet piling; TP-timber piling; C-concrete; B-brush. Improvements: REP-repaired; N-none; EXT-extended; RAIS-raised; REIN-reinforced; REC-reconstructed; REHAB-rehabilitated (key to letters in parentheses: DES-destroyed; REM-removed).

* Earlier work not included in current project.

** Insufficient information.

Table No.	Project Name	Project Type	Material	Length ft	Initial Construction	Improvements
			Alaska District (Concluded)			
9	Ketchikan Harbor					
	Thomas Basin	B(1)	S,C	940	1932	REP
	Bar Point Basin	B(4)	C	963	1979	N
			C	120	1979	N
			S	700	1958	N
			S	1,100	1958	N
10	Kodiak Harbor	B(2)	S	789	1957	REC
			S	1,250	1957	REC
11	Metlakatla Harbor					
	Old Harbor	B(1)	S	900	1956	N
	New Harbor	B(2)	S	1,255	1981	N
			S	1,150	1981	N
12	Ninilchik Harbor	J(2)	S	350	1967	REP
			S	350	1967	REP
13	Nome Harbor	J(2)	S,C,SS	240	1940	REP
			S,C,SS	400	1940	REP
		*	S	335	1920	REP,REC
		*	S	460	1935	REC
14	Pelican Harbor	B(1)	S	1,000	1957	N
15	Port Lions Harbor	B(2)	S	600	1981	REC,EXT
			S	170	1981	N
16	Seldovia Harbor	B(2)	S	400	1961	RAIS
			S	600	1961	RAIS
17	Seward Harbor	B(2)	S	1,060	1964	N
			S	1,750	1964	N
		*	S	580	1931	RAIS(DES)
		*	S	950	1937	RAIS(DES)
		*	TP	**	1956	N(DES)
		*	TP	**	1956	N(DES)
18	Sitka Harbor	B(2)	S	1,430	1964	N
			S	200	1964	EXT
19	Valdez Harbor	B(2)	S	625	1965	N
			S	685	1965	N
		*	S	475	1957	N(DES)
		*	TP	530	1957	REIN(DES)
20	Wrangell Harbor	B(1)	S	300	1926	N

(Continued)

Table No.	Project Name	Project Type	Material	Length ft	Initial Construction	Improvements
			Portland District			
21	Chetco River	J(2)	S	1,350	1957	RAIS,EXT
			S	1,350	1957	REHAB,RAIS
22	Columbia River at Mouth	J(3)	S	34,850	1895	REP,REHAB, EXT
			S	13,200	1917	REP,REHAB
			S	5,300	1939	REP,REHAB
23	Coos Bay	J(2)	S	9,600	1891	REP,REHAB
			S	**	1924	REP,REHAB
		B(1)	S	2,800	1957	REP,EXT
24	Coquille River	J(2)	S,C	3,450	1907	REHAB,EXT
			S	2,700	1907	REHAB
		B(1)	S	350	1982	N
25	Depoe Bay	B(2)	C	160	1952	N
			C	**	1966	N
26	Nehalem River	J(2)	S	4,500	1915	REHAB,RAIS
			S	3,300	1918	REHAB,RAIS
27	Port Orford	B(1)	S	550	1968	N
28	Rogue River	J(2)	S	3,400	1959	N
			S	3,300	1960	REHAB
29	Siuslaw River	J(2)	S	7,490	1917	REP,REHAB, EXT
			S	3,945	1917	REP,EXT
30	Tillamook Bay	J(2)	S	5,700	1914	REP,REHAB, RAIS
			S	8,000	1979	EXT
31	Umpqua River	J(3)	S,C	8,000	1930	REP,REHAB
			S	4,200	1934	REHAB,EXT
			S	4,240	1951	EXT
32	Yaquina Bay	J(2)	S	8,600	1895	REP,REHAB, EXT
			S	7,000	1895	REP,REHAB, EXT
		B(2)	TP,S	2,650	1948	N
			TP,S	400	1948	N
		B(2)	S	1,800	1978	N
			S	700	1978	N

(Continued)

Table No.	Project Name	Project Type	Material	Length ft	Initial Construction	Improvements
			Seattle District			
33	Anacortes Harbor	B(2)	TP	470	1957	EXT,REP
			TP	470	1957	EXT,REP
34	Bellingham Harbor	B(3)	S	**	1958	N
			S	**	1958	N
			S	1,500	1980	N
35	Blaine Harbor	B(3)	S	1,500	1957	N
			S	450	1957	N
			S	834	1957	N
36	Edmond's Harbor	B(2)	S	1,850	1962	N
			S,TP	250	1962	N
37	Gray's Harbor	J(2)	S	13,734	1898	REHAB,RAIS
			S	16,000	1910	REHAB,RAIS, EXT
38	Kingston Harbor	B(1)	S	1,040	1967	N
39	Lake Crockett	B(1)	S	**	1947	REP,EXT
40	Neah Bay	B(1)	S	8,000	1944	REP,REHAB, RAIS
41	Olympia Harbor	B(1)	C	656	1983	N
42	Port Angeles Harbor	B(2)	S,TP	1,026	1959	N
			S,TP	145	1959	N
43	Port Townsend Boat Basin	B(1)	S	1,946	1964	N
44	Quillayute River Boat Basin	B(2)	TP	**	**	N
			TP	**	**	N
		J(1)	S	1,400	1931	REP,RAIS EXT
45	Shilshole Bay	B(1)	S	4,440	1958	EXT
46	Swinomish Channel	J(3)	S	**	1893	REC
			S	**	1938	REHAB
			S,P	3,650	1908	REHAB,EXT

(Continued)

Table No.	Project Name	Project Type	Mate-rial	Length ft	Initial Construction	Improve-ments
			Seattle District (Concluded)			
47	Waterway Con-necting Port Townsend and Oak Bay	J(2)	B,TP,S	550	1916	REHAB,RAIS
			B,TP,S	660	1916	REHAB
48	Westhaven Cove Small-Boat Basin	B(5)	S,TP	970	1950	REIN
			S,TP	700	1950	N
			S,TP	1,550	1958	REC,EXT
			S,TP	260	1973	N
			S,TP	200	1979	N
49	Willapa River and Harbor and Naselle River	B(1)	S	1,500	1958	N

PART III: PROJECT DESCRIPTIONS

Alaska District

Cordova Harbor, Alaska

16. Cordova is located in southern Alaska on Orca Inlet at the southeastern approach of Prince William Sound, 145 air miles east-southeast from Anchorage. The original project was adopted in 1935 and completed in 1938, including an 8.26-acre boat basin dredged to -10 ft mean lower low water (mllw), a 1,100-ft north breakwater, and a 1,400-ft south breakwater, both of rubble-mound over brush mat construction. The harbor was originally designed for 500 boats, but increasing boat sizes reduced the capacity to 220 boats by 1964.

17. The 1964 earthquake uplifted the area 6.4 ft and reduced the depth of the harbor to -5.5 ft mllw. The harbor was restored--including repair and strengthening of both breakwaters, construction of an access road along the crest of the north breakwater, and dredging the original basin plus an additional 10.4 acres to -14 ft mllw--to provide a 305-boat capacity. Restoration was completed in 1965, and a 183-ft entrance breakwater was added in 1966.

18. In 1981 the harbor was expanded by 19.55 acres by removing the 1,400-ft south breakwater, extending an existing silt barrier breakwater by 650 ft, and constructing a 1,902-ft rubble-mound breakwater along the west and north sides of the extended basin. The basin extension was dredged by local interests. The project was completed in 1983 and appears to be in good condition at this time. A chronology of events related to the development and repair of the harbor structures is given in Table 1.

Craig Harbor, Alaska

19. Craig is located in southeastern Alaska on the west side of Prince of Wales Island, 60 air miles west of Ketchikan and 750 miles southeast of Anchorage. The project includes a small-boat basin protected by two breakwaters.

20. The original project was adopted in 1945 and provided for dredging a basin in South Cove to -11 ft mllw and a 100-ft wide entrance channel to -11 ft mllw. The floating dock system was expanded toward the harbor entrance in 1975 to provide moorage for the growing fishing fleet. The expanded area was subjected to winter storms. After one ship sank and several others were

damaged during a 1977 storm, the expanded section of the dock was closed during the winter months. To protect the expanded dock area, the Corps constructed two short rubble-mound breakwaters during 1981 to 1983. A chronology of events related to the development and repair of the harbor structures is given in Table 2.

Douglas Small-Boat Basin, Alaska

21. Douglas is located on Douglas Island, Alaska, across the Gastineau Channel about 2 miles southeast of Juneau. The project, as adopted in 1958, includes a 5.2-acre small-boat basin dredged to -12 ft mllw and a 90-ft rubble-mound breakwater.

22. The project was completed in 1962, including a 105-ft rubble-mound breakwater. To maximize the area of the harbor, 1:3 side slopes were dredged on the southeast and southwest sides of the basin. These slopes were covered with a 2-ft filter layer of gravel under a 2-ft layer of quarry run rock for slope protection. The other sides of the basin were dredged to 1:10 slopes and did not require protection. A chronology of events related to the development and repair of the harbor structures is given in Table 3.

Haines Small-Boat Basin, Alaska

23. Haines Small-Boat Basin is located on the west shore of Portage Cove, adjacent to the City of Haines in southeast Alaska, about 90 water miles northwest of Juneau, Alaska. The project includes the extension of an existing small-boat basin by removal of part of an existing breakwater and construction of a 905-ft offshore rubble-mound breakwater.

24. The existing small-boat basin was constructed by a joint effort of the Territory of Alaska and Alaska Public Works, a one-time Department of the Interior agency. The basin was protected by an 800-ft L-shaped breakwater completed in 1958. The basin was intended to enclose a 2.5-acre basin dredged to -10 ft mllw. Difficulties in dredging the basin resulted in only 1.8 acres being completed.

25. The Corps project was adopted in 1971 and included expansion of the basin to 4.2 acres dredged to -12 ft mllw and -14 ft mllw, with an entrance channel dredged to -15 ft mllw, removal of the seaward leg of the existing breakwater, and construction of a 905-ft crescent-shaped offshore rubble-mound breakwater. The project was completed in 1976. A chronology of events related to the development and repair of the harbor structures is given in Table 4.

Homer Harbor, Alaska

26. Homer is located on lower Cook Inlet in southern Alaska, approximately 125 air miles south of Anchorage and 70 miles north of Kodiak. The project includes a small-boat basin protected by a berm and two breakwaters. The harbor is located near the outer end of Homer Spit, a naturally occurring spit extending 3.5 miles into Kachemak Bay.

27. The project was originally adopted in 1958 and completed in 1962, including a 2.8-acre basin protected by a 1,260-ft rubble-mound breakwater. The basin was destroyed and the breakwater severely damaged in the 1964 earthquake. In 1965 the basin was restored and relocated slightly to the northwest of the original basin. The restored basin included 10 acres with 2.75 acres at -12 ft mllw and 7.25 acres at -15 ft mllw, a 1,018-ft main breakwater, and a 238-ft secondary breakwater. Local interests expanded the basin to 16.5 acres during 1968 to 1970.

28. The project was expanded to 50 acres during 1984 to 1985 by extending the basin 1,040 ft to the northwest and 350 ft to the northeast. The harbor is protected on the northeast by a berm with a 220-ft crest width allowing 2-lane vehicular access. A chronology of events related to the development and repair of the harbor structures is given in Table 5.

Hoonah Harbor, Alaska

29. Hoonah is located on the northeastern shore of Chichagof Island in southeastern Alaska on the eastern shore of Port Frederick, 70 miles west of Juneau. The project includes a 15.5-acre small-boat basin protected by an 800-ft and a 1,507-ft rubble-mound breakwater, a 140-ft rubble-mound entrance breakwater, and an 800-ft and a 1,165-ft rubble-mound diversion dike. Construction began in 1979 and was completed in 1980. The basin provides moorage for 105 local and transient commercial fishing vessels, with provisions for expansion to 225 boats. A chronology of events related to the development and repair of the harbor structures is given in Table 6.

Humboldt Harbor, Alaska

30. Sand Point is located on the northern shore of Humboldt Harbor on the western side of Popof Island in the Shumagin Island group of southwestern Alaska, approximately 560 air miles southwest of Anchorage. The project includes a 16.6-acre mooring basin protected by a 1,025-ft north breakwater, a 740-ft south breakwater, and a 1,175-ft diversion dike. The basin was constructed during 1975 to 1976. A chronology of events related to the

development and repair of the harbor structures is given in Table 7.

Juneau Harbor, Alaska

31. Juneau is located in southeastern Alaska along the Gastineau Channel, 900 air miles northwest of Seattle, Washington, and 575 air miles southeast of Anchorage, Alaska. The city is accessible only by air or sea.

32. Juneau Harbor includes Harris Basin and Aurora Basin. Harris Basin was completed in 1939 and includes 11.5 acres protected by a 430-ft and a 1,540-ft breakwater. The adjacent Aurora Basin covers 19 acres and is protected by a 670-ft jetty and a 1,500-ft composite rubble-mound steel pile with treated planking breakwater. The harbor is part of the Juneau-Douglas complex, which also includes Douglas Harbor and Gastineau Channel. A chronology of events related to the development and repair of the harbor structures is given in Table 8.

Ketchikan Harbor, Alaska

33. Ketchikan is located on the southwestern side of Revillagigedo Island in the Alexander Archipelago of southeastern Alaska, approximately 700 nautical miles north of Seattle, Washington, via the Inland Passage, and 760 air miles southeast of Anchorage, Alaska. The project includes the 11.35-acre Thomas Basin and the 36.9-acre Bar Point Basin.

34. The Thomas Basin project was adopted in 1930 and completed in 1932. The basin was dredged to -10 ft mllw and is protected by a 940-ft stone breakwater. An 840-ft concrete cap was added to the crest of the breakwater in 1933.

35. The original Bar Point Basin was authorized in 1954 and constructed in 1958. The basin includes 11.9 acres protected by a 1,100-ft detached breakwater and a 700-ft south breakwater, both of rubble-mound construction. The basin was expanded in 1979 by the addition of two floating breakwaters, 963 and 120 ft long. A chronology of events related to the development and repair of the harbor structures is given in Table 9.

Kodiak Harbor, Alaska

36. Kodiak is located on the northeast shore of Kodiak Island on the north side of Chiniak Bay in the western Gulf of Alaska, about 1,250 air miles northwest of Seattle, Washington, 650 miles west of Juneau, Alaska, and 250 air miles southwest of Anchorage, Alaska. The project includes an 11.7-acre basin protected by a 1,250-ft and a 780-ft breakwater.

37. The original project included a channel, 200 ft wide by 22 ft deep

at mllw, between Kodiak Island and Near Island. The project was modified in 1954 to include the small-boat basin. In 1964, the earth subsided about 5 ft in an earthquake, causing severe damage to the basin and the breakwaters. The breakwaters were rebuilt the same year.

38. The basin, along with a small basin named Old Harbor, provide the only harbors-of-refuge between Cook Inlet and the Shumagin Islands. An extension to the harbor was recommended in 1976 by constructing two breakwaters on Near Island to protect a 45-acre basin. In 1984, further study on the extension was determined to be unwarranted due to the severe decline in the local shellfish fishery. A chronology of events related to the development and repair of the harbor structures is given in Table 10.

Metlakatla Harbor, Alaska

39. Annette Island is located in southeastern Alaska, 16 water miles south of Ketchikan, Alaska, and 650 air miles northwest of Seattle, Washington.

40. The original basin was adopted in 1945 and completed in 1956. The harbor included 2.18 acres protected by a 900-ft rubble-mound breakwater. A second harbor was adopted in 1972 and completed in 1982. The new harbor provides 5.75 acres protected by a 1,255-ft and a 1,150-ft rubble-mound breakwater. The harbor capacities are 42 boats in the original harbor and 100 boats in the new harbor. A chronology of events related to the development and repair of the harbor structures is given in Table 11.

Ninilchik Harbor, Alaska

41. Ninilchik is located on the eastern shore of Cook Inlet, about midway between Kenai and Homer, 110 air miles or 187 road miles southwest of Anchorage. The harbor is located near the mouth of the Ninilchik River. The harbor was authorized in 1958, including a 320-ft by 150-ft basin dredged to +2 ft mllw, an entrance channel, and a 410-ft-long pile jetty located 50 to 100 ft south of the channel entrance.

42. The harbor was completed in 1961, including a 400- by 120-ft basin with rock sills upstream and downstream of the basin. The pile jetty was deleted. In 1967 the harbor underwent a major rehabilitation, including construction of two rock pile jetties at the mouth of the river. The harbor has required dredging or repairs every year since completion. Dredging has averaged 9,500 to 9,945 cu yd per year, and a log revetment for beach erosion control has required annual maintenance.

43. The harbor was designed for a capacity of 32 boats; yet it supports a 110-boat fishing fleet, and as many as 140 boats have been moored in the harbor at one time. A study conducted by the Corps during 1980 to 1984 found that plans to expand the basin to relieve the overcrowding were not economically justifiable. A chronology of events related to the development and repair of the harbor structures is given in Table 12.

Nome Harbor, Alaska

44. Nome is located on the southern coast of the Seward Peninsula in northwest Alaska, 535 air miles northwest of Anchorage and 520 air miles west of Fairbanks. The mouth of the Snake River is protected by a 400-ft rubble-mound west jetty and a 240-ft rubble-mound east jetty.

45. The shallow entrance channel and small basin require that barges be anchored offshore and cargo transferred via lighters. The harbor is typically iced over from mid-November to May, and the ice may extend 3,000 to 6,000 ft into the sound with 20- to 30-ft high pressure ridges at the seaward margin of the ice sheet. Waves are typically short, steep, and less than 3 ft high. The significant wave height used in the design of the shore structures was 12 ft. A chronology of events related to the development and repair of the harbor structures is given in Table 13.

Pelican Harbor, Alaska

46. Pelican is located on Lisianski Inlet off the north shore of Chichagof Island in southeastern Alaska, about 100 miles west of Juneau. The project includes a 5.74-acre small-boat basin protected by a 1,000-ft rubble-mound breakwater. The project was adopted in 1954 and completed in 1958. A chronology of events related to the development and repair of the harbor structures is given in Table 14.

Port Lions Harbor, Alaska

47. Port Lions is located on the northern end of Kodiak Island, 19 miles west of the City of Kodiak. The city was founded in 1965 when the government relocated residents of the town of Afognak, which had been destroyed in the 1964 earthquake. The project includes a small-boat basin protected by two breakwaters.

48. The study was authorized in 1965 and the project approved for construction by the Office of the Chief of Engineers in 1977. The project included an undredged 12-acre mooring basin protected by a 650-ft and a 500-ft breakwater. At the request of local interests, an alternate plan was adopted,

including a 5-acre basin protected by a 600-ft main breakwater and a 170-ft stub breakwater. The main breakwater was destroyed by a storm in 1981 and rebuilt and extended to 725 ft in 1983. The basin has a capacity of 125 boats. A chronology of events related to the development and repair of the harbor structures is given in Table 15.

Seldovia Harbor, Alaska

49. Seldovia is located near the mouth of Seldovia Bay on the southern shore of Kachemak Bay on Cook Inlet, 140 air miles south of Anchorage and 15 nautical miles southwest of Homer. The project includes a 700-ft by 300-ft boat basin dredged to -12 ft mllw, protected by a 400-ft north breakwater and a 600-ft detached south breakwater.

50. The project was authorized in 1958 and constructed during 1961 to 1962. An earthquake in 1964 caused the basin to subside 3.8 ft. The breakwaters were therefore raised 4 ft in 1964. A chronology of events related to the development and repair of the harbor structures is given in Table 16.

Seward Harbor, Alaska

51. Seward is located on Resurrection Bay off the Gulf of Alaska, about 120 miles south of Anchorage. The project includes a 17-acre small-boat basin protected by two rubble-mound breakwaters.

52. The original project, authorized in 1930 and completed in 1932, included a 4.7-acre basin dredged to -12.5 ft mllw, protected by a 580-ft south breakwater. A 950-ft north breakwater was added in 1937 and raised in 1953. During 1955 to 1956, the south breakwater was raised, and two pile breakwaters were added on the eastern side of the basin.

53. The original harbor was completely destroyed in the 1964 earthquake. The harbor was relocated and rebuilt during 1964 to 1965, including a 4.75-acre replacement basin dredged to -12.5 ft mllw, a 12.45-acre extension dredged to -15 ft mllw, a 1,060-ft rubble-mound south breakwater, and a 1,750-ft rubble-mound east breakwater.

54. A Detailed Project Report and Final Environmental Impact Statement were prepared in 1982 for expansion of the harbor. The study recommended that a 30-acre basin be dredged 2 miles northeast of Seward, protected by a 1,400-ft south breakwater, a 2,500-ft west breakwater, and a 1,700-ft north silt-barrier breakwater. There was no record of action taken since the study was prepared. A chronology of events related to the development and repair of the harbor structures is given in Table 17.

Sitka Harbor, Alaska

55. Sitka is located on the western shore of Baranof Island on Sitka Sound in southeastern Alaska. There are three harbors located at Sitka: Crescent Bay, A. N. B., and Thomsen harbors. Crescent Bay harbor is the only harbor under Corps jurisdiction at Sitka.

56. The project, authorized in 1945 and constructed during 1964 to 1965, includes a 15-acre basin dredged to -10 ft mllw protected by a 1,430-ft main breakwater and a 200-ft entrance breakwater. The entrance breakwater was extended by 135 ft during 1972 to 1973 due to damage to small craft within the harbor. A chronology of events related to the development and repair of the harbor structures is given in Table 18.

Valdez Harbor, Alaska

57. Valdez is located in the northeastern corner of Prince William Sound in southcentral Alaska, 110 air miles and 305 road miles from Anchorage. It is the southern terminus of the trans-Alaska pipeline and is generally regarded as the northernmost ice-free port in Alaska.

58. The original harbor, authorized in 1938 and completed in 1939, included a small-boat and seaplane harbor of approximately 3 acres dredged to -12 ft mllw. In 1954, a 475-ft rock and gravel breakwater on the southeastern side, and a 530-ft pile breakwater on the southern and western sides were authorized. The breakwaters were completed in 1957. A protective rock and gravel base was added to the pile breakwater in 1960.

59. The entire basin and facilities were destroyed by the earthquake in 1964. A relocated and enlarged basin was authorized in 1964 and completed in 1965, including a 10-acre basin protected by a 625-ft west breakwater and a 685-ft east breakwater. Local interests expanded the basin to 19 acres in 1985. A chronology of events related to the development and repair of the harbor structures is given in Table 19.

Wrangell Harbor, Alaska

60. Wrangell is located at the northern end of Wrangell Island near the northern end of Zimovia Strait in southeastern Alaska, 739 nautical miles northwest of Seattle and 149 miles south of Juneau. The town is situated on the Wrangell Narrows, a Corps-maintained channel through which passes the major portion of all commerce enroute to Alaskan ports.

61. The original project provided for construction of a 300-ft breakwater at Point Shekesti. The breakwater was authorized in 1922 and

constructed in 1926. A 600- by 400-ft basin dredged to -10 ft mllw (outer basin) was authorized in 1935 and dredged in 1936. An inner basin, 550 ft long by 325 ft wide (dredged to -10 ft mllw), a connecting channel, and a 320-ft breakwater were authorized in 1945. The basin and connecting channel were dredged during 1956 to 1957; the 320-ft breakwater was deferred. A chronology of events related to the development and repair of the harbor structures is given in Table 20.

Portland District

Chetco River, Oregon

62. The mouth of the Chetco River is located on the southern Oregon coast, about 4 miles north of the Oregon-California border. The Town of Brookings, Oregon, is situated along the mouth of the river.

63. Authorized in 1945, the original project included an 850-ft north jetty and a 1,550-ft south jetty, both completed in 1957; and removal of rock pinnacles and abandoned bridge piers was completed in 1959. In 1962, the outer 440 feet of the south jetty was repaired and raised. The project was modified in 1965 to include a 450-ft extension to the north jetty and to raise the rest of the north jetty to +16 ft mllw (completed in 1968). Construction of a 1,800-ft protective dike to +18 ft mllw was completed in 1970. Extensions of both jetties and deepening of the channel were recommended in 1977 (the General Design Memorandum having been initiated in 1982), but funds have not yet been made available. A chronology of events related to the development and repair of the jetty structures is given in Table 21.

Columbia River at Mouth, Oregon and Washington

64. The Columbia River is the largest river on the Pacific coast of the United States, with a length of 1,210 miles and a drainage basin of 259,000 sq. miles. Extensive and shifting shoals, known as Clatsop Spit, extended north and west from Point Adams on the south side of the river mouth, making navigation into the river hazardous. On the north side of the mouth is Cape Disappointment, about 6 miles north-northwest from Point Adams. Shoals off the southern end of Cape Disappointment are known as Peacock Spit. The ocean bar connects Peacock Spit and Clatsop Spit.

65. In 1882, Congress authorized a board of engineers to develop a plan

for improvement of conditions at the mouth of the river. The report, submitted in 1882, recommended a jetty extending from the shore near Fort Stevens (on Point Adams) in a northwest direction toward a point 3 miles south of Cape Disappointment and possibly a jetty on Peacock Spit. Construction on the jetty began in 1885. In 1893 a board of engineers was convened to determine the effects of the work and recommend any changes. The board recommended that four groins be constructed on the north side of the jetty and that the jetty be raised to elevation +12 ft at shore, slope to +10 ft at 1.125 miles from shore, and slope to +4 ft at the outer end (all elevations referenced to a datum of mean low water (mlw)). The total length of the south jetty was 4.5 miles. All recommendations were adopted, and the south jetty was completed in 1895. The jetty was rubble mound and built from trestle work.

66. In 1889 the channel depth was -20 ft mllw and had a bearing west of south. With the construction of the south jetty, the channel shifted to due west and increased in depth to -31 ft mllw by 1895. The channel depth remained -30 ft mllw in 1896 and 1897 and then started to decrease as the channel continued to shift to the north. By 1902, the channel ran almost due north and was at -22 ft mllw, while two new channels with about the same depth had formed in the western section of the bar.

67. A new study of the mouth of the river was authorized in 1899. The engineers conducting the study submitted their report in 1903, and they recommended extending the south jetty due west for 2.5 miles, constructing a north jetty from Cape Disappointment to a point 2 miles north of the outer end of the 2.5-mile extension to the south jetty, and dredging.

68. The extension of the south jetty was begun in 1903 and completed in 1913. Wave action prevented repair operations by floating plant, so no maintenance was done until the amount of work needed could justify the cost of the trestle and plant. By 1931 the jetty had been lowered to about mean low water. The jetty was restored, except for the outer 3,300 ft, between 1931 and 1936, using 2,200,000 tons of stone. Wave action then started destroying the end face, causing the superstructure to ravel back 300 ft or more during a normal winter season. The outer end was therefore impregnated with 12,737 tons of a mixture of 18 percent asphalt and 82 percent beach sand in 1937. The asphalt failed to secure the end of the jetty, and a concrete terminal was constructed above the low water level during 1941 to 1942. The concrete terminal was about 3,900 ft shoreward from the end of the original

jetty as completed in 1913, and it has proven effective. The width of the south jetty crest varies from 45 to 70 ft, with a crest elevation of +26 ft mllw and side slopes of 1:1.5. The jetty is constructed of stones up to 25 tons each, 45 percent having an average weight of 10 tons each. The base width of the outer portion is approximately 350 ft, and the total height ranges up to 76 ft.

69. The design wave on the south jetty is the depth-limited breaking wave and varies from 19 to 22 ft.

70. The north jetty was constructed between 1913 and 1917. The crest elevation was +28 to +32 ft mllw, with a crest width of 25 ft and side slopes of 1:1.5. The jetty started on the west side of Cape Disappointment, extended southwestward for about 2 miles to a point 2 miles north of the south jetty, then turned westward for about 1,700 ft. The jetty contained nearly 3 million tons of stone.

71. The outer portion of the north jetty was flattened by wave action to mean low water by 1930, but the 2-miles-long southwesterly leg was backed up by a natural sand fill on the northerly side and was thus protected. Some damage resulted along the southeasterly side from river undercutting. The jetty was rehabilitated during 1938 to 1939 and a concrete terminal placed at the end of the southwestward segment. The outer portion extending westerly was not reconstructed and serves as an apron on the sea slope.

72. In conjunction with the rehabilitation of the north jetty, two spur jetties were proposed to help maintain the channel. Jetty "A" started at Cape Disappointment and extended in a southerly direction for about 1 mile. The jetty has experienced frequent problems with scour at the head of the jetty, and most repair work has been a result of the scour. Jetty "B" was not constructed and has been classified "inactive". A chronology of events related to the development and repair of the jetty structures is given in Table 22.

Coos Bay, Oregon

73. Coos Bay is located on the southern Oregon coast about 200 miles south of the mouth of the Columbia River and 445 miles north of San Francisco Bay. The project includes two jetties at the mouth of the bay and a small-boat mooring basin at the Town of Charleston, about 1 mile from the mouth of the bay.

74. The initial study for navigation improvements, authorized in 1878, recommended that two parallel jetties be constructed seaward from the mouth of

Coos Bay to stabilize the channel and that sand fences be constructed to prevent windblown sand from extending the spit. Instead, a spur jetty was authorized in 1879. In 1889, a board of engineers recommended that work on the spur jetty be halted and that two parallel jetties be constructed at the mouth of the bay.

75. The north jetty was constructed to a 9,600-ft length between 1891 and 1895 and restored between 1923 and 1929. The south jetty was constructed in 1929 and 1930.

76. A small-boat mooring basin in South Slough at Charleston was authorized in 1948. The project included a 2,100-ft breakwater. The project was constructed during 1956 to 1957 and then expanded by local interests in 1966. A chronology of events related to the development and repair of the jetty and harbor structures is given in Table 23.

Coquille River, Oregon

77. The mouth of the Coquille River is located on the southern Oregon coast about 225 miles south of the mouth of the Columbia River and 420 miles north of San Francisco Bay. The town of Bandon, Oregon, is located at the mouth of the river.

78. The project includes a 3,450-ft north jetty and a 2,700-ft south jetty, both of rubble-mound construction, authorized in 1880 and completed in 1907.

79. The outer 1,600 ft of the north jetty was rerocked and capped with concrete in 1942 and repaired again in 1956. A 750-ft shoreward extension was added to the east end of the north jetty in 1951. The outer 450 ft of the south jetty was repaired in 1954.

80. Currently, the north jetty head is in need of repair but is still functional. The south jetty is in good shape. A chronology of events related to the development and repair of the jetty structures is given in Table 24.

Depoe Bay, Oregon

81. Depoe Bay is a small, rock-bound tidal basin on the Oregon Coast about 100 mi south of the Columbia River, measuring roughly 500 ft by 1,000 ft at high tide. The entrance to the bay is a narrow opening between rocky bluffs that connects the bay to an outer cove and the open sea. The entrance is about 300 ft long by as little as 20 ft wide at project depths and 100 ft wide at high waterline.

82. The original project, authorized in 1937 and completed in 1939,

included an inner basin 375 by 125 by 5 ft deep at mllw, and an entrance channel 5 ft deep at mllw by 30 ft wide. An expansion to the project was authorized in 1945, including deepening the channel and enlarging the basin, constructing a 160-ft breakwater outside the north entrance to the bay, and constructing a retaining wall along the easterly side of the basin. The expansion was completed around 1950. In 1960, another expansion was authorized, including constructing a second breakwater on the northern entrance to the bay and widening the entrance channel.

83. The project is in good condition at this time. There is no record of either breakwater requiring maintenance since its construction. A chronology of events related to the development and repair of the harbor structures is given in Table 25.

Nehalem River, Oregon

84. Nehalem Bay is located at the mouth of the Nehalem River, about 40 miles south of the mouth of the Columbia River, on the Pacific coast of Oregon. In the latter half of the 1800's, local interests repeatedly petitioned the Corps for construction of jetties to maintain a channel across the bar. Unfavorable survey reports in 1875, 1884, and 1886 prevented the work from being started.

85. In 1890, the construction of two high-tide jetties at the mouth of the river was authorized at an estimated cost of $326,000. In 1891 the estimated cost was increased to $712,000. The project was terminated in 1898 without any construction being started.

86. The existing project was authorized in 1912, including two converging, high-tide, rubble-mound jetties, 700 ft apart at the outer ends, with the north and south jetties being 3,850 and 4,950 ft long, respectively. The south jetty included work begun by local interests in 1910, and local interests would pay one-half the costs of construction of the two jetties. The south jetty was completed in 1915; the north jetty was completed in 1918.

87. No repairs were made to the jetties, and the project was classified inactive in 1934. In 1981, both jetties were given major rehabilitation and are currently in good condition. A chronology of events related to the development and repair of the jetty structures is given in Table 26.

Port Orford, Oregon

88. Port Orford is located on the southern Oregon coast, 250 miles south of the Columbia River and 390 miles north of San Francisco Bay. The

project, authorized in 1956 and constructed in 1968, consists of a 550-ft extension to an existing, locally-constructed breakwater to protect the harbor from winter storms from the south and southwest. A chronology of events related to the development and repair of the harbor structures is given in Table 27.

<u>Rogue River, Oregon</u>

89. The mouth of the Rogue River is located on the southern Oregon coast, 264 mi south of the mouth of the Columbia River and 319 mi north of San Francisco Bay. The town of Gold Beach, Oregon, is located at the mouth of the river.

90. The project includes two rubble-mound jetties. The south jetty, 3,400 ft long, was completed in 1959; the 3,300-ft north jetty was completed in 1960. The north jetty, undercut by river action and damaged during a 1964 flood, was rehabilitated in 1966.

91. Local interests have constructed a small-boat basin on the south side of the river, protected by a breakwater. The Corps provided an entrance channel and turning basin for the basin in 1972.

92. Both jetties show sporadic localized damage but are still functional. No repair work is planned for the near future. A chronology of events related to the development and repair of the jetty structures is given in Table 28.

<u>Siuslaw River, Oregon</u>

93. The mouth of the Siuslaw River is located on the southern Oregon coast 154 miles south of the mouth of the Columbia River. The town of Florence, Oregon, is located about 5 miles upstream from the mouth of the river.

94. The project provides for a pair of high-tide rubble-mound jetties and a channel extending from the mouth of the river upstream to mile 16.5 near Mapleton, Oregon. The project was originally authorized in 1890 and revised in 1891. It included a 7,500-ft north jetty and a 5,600-ft south jetty, 600 ft apart at the ends. The project was suspended in 1905, at which time the north jetty had been constructed to 4,090 ft, and the south jetty had not been started.

95. The present project was authorized in 1910 and included extension of the north jetty by 3,700 ft and a 4,200-ft south jetty, with the jetties separated by 750 ft at their ends. The jetties were completed in 1917, at

which time the north jetty was 7,490 ft long and required 441,237 tons of stone, and the south jetty was 3,945 ft long and required 196,860 tons of stone. Both jetties had a crest elevation of +15 ft mllw, crest widths of 15 to 20 ft, and side slopes of 1:1.5 to 1:2.

96. The north jetty was rehabilitated during 1957 to 1958. A 600-ft extension to the north jetty was authorized in 1958, but it was deferred until, in the opinion of the District Engineer, the extension was advisable. In 1981, the Design Memorandum was prepared for extending the north jetty by 2,000 ft, including the 600-ft extension authorized in 1958, and extending the south jetty by 2,500 ft. The extensions have not been constructed. A chronology of events related to the development and repair of the jetty structures is given in Table 29.

<u>Tillamook Bay, Oregon</u>

97. Tillamook Bay is located on the Pacific coast of Oregon, about 47 miles south of the Columbia River. The project includes two rubble-mound jetties protecting the entrance to the bay and a dike repairing a breach in a spit on the westerly side of the bay.

98. The 5,700-ft-long north jetty was authorized in 1912 and constructed during 1912 to 1914 to 5,400 ft. The jetty was reconstructed during 1931 to 1933, including a 300-ft extension, to the full authorized length. The jetty was rehabilitated during 1963 to 1965 to repair damage caused by undermining of the structure. The jetty head has received some damage from extreme wave conditions, but no improvements are planned at this time.

99. The 8,000-ft south jetty was authorized in 1965, and construction of the first 5,000 ft was initiated in 1969. Deep scouring of the bottom ahead of the jetty caused overruns, and construction was halted at a length of 3,695 ft in 1971. The jetty was extended 2,830 ft during 1972 to 1974, and the distance between the jetties was decreased from 1,400 to 1,200 ft. The jetty was extended to the full authorized length of 8,000 ft during 1978 to 1979. The final leg of the jetty has shown some subsidence, but no repair work is planned at this time. A chronology of events related to the development and repair of the jetty structures is given in Table 30.

<u>Umpqua River, Oregon</u>

100. The Umpqua River flows into the Pacific Ocean on the Oregon coast about 178 miles south of the Columbia River. The town of Reedsport, Oregon, is located 12 miles upstream from the mouth of the river.

101. The existing project was adopted in 1922, providing a 7,500-ft jetty on the northern side of the mouth by extending a 3,390-ft jetty constructed by local interests during 1916 to 1919. Construction began in 1923, was halted in 1926 due to lack of funds with the jetty 70 percent complete, and completed during 1928 to 1930. The jetty was restored during 1941 to 1942, including placing a concrete cap on the outer 3,977 ft.

102. A short south jetty was authorized in 1930 and constructed during 1933 to 1934. In 1935, a 1,700-ft extension was authorized. The work was completed in 1938, including a monolithic concrete block, 46 ft long by 30 ft wide by 16 ft high, placed at the head of the extension and flanked by four wing blocks and two end blocks. The south jetty was then 4,200 ft long and terminated 1,800 ft south of the end of the north jetty. A 550-ft shore connection was added in 1940.

103. The original jetties did not provide an adequate entrance. In addition, the ebb currents met the south jetty at an abrupt angle, causing deterioration and subsidence of the structure. A hydraulic model study was conducted at the US Army Engineer Waterways Experiment Station (WES) during 1946 to 1948 to determine the best method of improvement. Based on the model study results, a 4,240-ft training jetty was constructed parallel to and along the south side of the entrance channel during 1950 to 1951. The training jetty terminated about one-half mile short of the end of the south jetty.

104. The south jetty was rehabilitated in 1963. In 1964, a second hydraulic model study was initiated at WES which recommended extending the training jetty to the end of the south jetty. The north jetty was rehabilitated in 1977, and the training jetty was extended during 1978 to 1980.

105. The jetties appear to be in good condition at this time. A chronology of events related to the development and repair of the jetty structures is given in Table 31.

Yaquina Bay, Oregon

106. Yaquina Bay is located on the Pacific coast of Oregon, 113 miles south of the Columbia River. The town of Newport, Oregon, is located at the mouth of the bay.

107. The original project was authorized in 1880 and included two converging high-tide rubble-mound jetties. The north jetty extended 2,300 ft to the present angle in the jetty, and the south jetty was 3,600 ft long, with the ends of the jetties 1,000 ft apart. The orientation of the jetties was

intended to direct the channel through a break in a rocky reef located 4,000 ft offshore.

108. Authorization was given in 1919 to restore and extend the jetties. In 1921, the south jetty was extended to 5,800 ft, and an 800-ft spur dike and five groins were added to the channel side of the jetty. Work on the north jetty was completed in 1930 with the jetty extended to 3,700 ft.

109. The southwesterly orientation of the jetties exposes the north jetty to broadside attack by waves from northwest storms. The north jetty has accordingly required frequent rehabilitation, with major work performed during 1933 to 1934, 1939 to 1940 (including extension to 4,700 ft), 1956, 1966 (including extension to 7,000 ft), and 1977 to 1978. The 1977 work included blasting to sandseal the jetty to reduce littoral transport through the structure.

110. The south jetty was restored during 1933 to 1934, and extended 1,800 ft in 1969.

111. Two pile, timber, and stone breakwaters were built in the bay in 1948 to protect a small-boat basin at Newport, Oregon. The main detached breakwater was 2,650 ft long; the shore wing was 400 ft long. Both breakwaters were constructed to +14 ft mllw. A second marina was constructed in 1978 at Southbeach, Oregon. The marina was protected by a 1,800-ft west breakwater and a 700-ft north breakwater. Both Southbeach Marina breakwaters were of rubble-mound construction with a crest elevation of +14 ft mllw and crest width of 10 ft.

112. The south jetty and the breakwaters are currently in good condition. The outer 400 ft of the north jetty has deteriorated, and studies are being conducted to rehabilitate the structure. A chronology of events related to the development and repair of the jetty and harbor structures is given in Table 32.

Seattle District

Anacortes Harbor, Washington

113. Anacortes is located on Fidalgo Island on the east side of Puget Sound. The project includes a 2,850-ft-long channel in Capsante Waterway and a mooring basin protected by two pile breakwaters.

114. The project was adopted in 1919 and modified in 1954 to include

the boat basin and the breakwaters. The pile breakwaters, one 370 ft long located southeast of the basin and one 350 ft long located south of the basin, were completed in 1957. The southeast breakwater was extended to 440 ft by local interests in 1958, and both breakwaters were extended to 470 ft in 1964. Both breakwaters required rehabilitation in 1976. The Port of Anacortes enlarged the mooring basin in 1982. A chronology of events related to the development and repair of the harbor structures is given in Table 33.

Bellingham Harbor, Washington

115. Bellingham is located on the east side of Puget Sound in northern Washington. The project includes three waterways maintained by dredging, a small-boat basin protected by two rubble-mound breakwaters, and an expansion of the basin protected by a rubble-mound breakwater.

116. The small-boat basin was authorized in 1954, including two rubble-mound breakwaters with a combined length of 3,900 ft and the removal of an existing breakwater and dredging and maintenance of an entrance channel. The harbor was expanded in 1980 under authority of the 1960 River and Harbor Act. The expansion included construction of a 1,500-ft rubble-mound breakwater and dredging of entrance and access channels and a turning basin. A chronology of events related to the development and repair of the harbor structures is given in Table 34.

Blaine Harbor, Washington

117. Blaine Harbor is located on the US-Canadian border in the northwest corner of the State of Washington. The project includes a 14.7-acre expansion of an existing mooring basin, construction of a 1,500-ft rubble-mound breakwater, and reinforcement and maintenance of an existing 850-ft breakwater.

118. The project was authorized in 1954 and completed in 1957. Local interests established a small-boat basin at the site in 1936 and gradually enlarged it to 11.1 acres by 1956. The basin was protected by a 130-ft untreated pile breakwater, a 400-ft treated pile breakwater, an 834-ft two-step untreated wood pile and rock breakwater, a 450-ft rubble-mound breakwater, and a 9,260-ft bulkhead. The project converted 3.5 acres of the existing basin into an entrance channel and added 14.7 acres to the basin, protected by construction of a 1,500-ft rubble-mound breakwater extending from the existing rubble-mound breakwater to the existing two-step breakwater. The treated and untreated timber pile breakwaters are maintained by the Port of Bellingham.

The project included rock reinforcement of the two-step breakwater and repair of the existing rubble-mound breakwater. A chronology of events related to the development and repair of the harbor structures is given in Table 35.

Edmond's Harbor, Washington

119. Edmonds is located on the southeastern coast of Puget Sound, about 15 miles north of Seattle, Washington. The project includes maintenance of two breakwaters and an entrance channel to the basin.

120. The harbor was constructed by local interests in 1962, and it includes a mooring basin, a rubble-mound breakwater 1,850 ft long with a crest elevation of +18.5 ft mllw, a rock-reinforced treated pile and plank breakwater about 250 ft long, and an entrance channel. The Corps project, adopted in 1965, provides for maintenance of the two breakwaters and the entrance channel. Condition surveys are made annually, but there is no record of maintenance work being done. Local interests extended the basin to the north in 1968 and are responsible for all maintenance on the extended basin. A chronology of events related to the development and repair of the harbor structures is given in Table 36.

Gray's Harbor, Washington

121. Gray's Harbor is located on the Pacific coast of Washington, about 50 miles north of the Columbia River. The project, adopted in 1896 and modified by 13 subsequent Acts, includes a deep-draft navigation channel about 30 miles long in the harbor and the Chehalis River. The outer portion of the channel is protected by a 13,734-ft-long south jetty and a 17,200-ft-long north jetty; the inner portions are maintained by dredging.

122. The south jetty was completed in 1902. The north jetty was finished in 1913, then restored, lengthened, and raised in 1916. The jetties were constructed by end-dumping from railroad cars, which failed to provide a well-keyed section. The jetties therefore deteriorated by displacement of individual stones by wave forces. Further deterioration was caused by subsidence due to unstable foundation conditions. The south jetty was reconstructed during 1936 to 1939 and the north jetty during 1941 to 1942. Both jetties continued to deteriorate after the reconstruction. Hydraulic model studies were conducted during 1950 to 1952 and 1969 to 1971.

123. After the reconstruction of the north jetty during 1941 to 1942, a natural channel was maintained across the bar, and no further maintenance dredging has been required. Deterioration of the north jetty allowed the

predominantly southerly littoral drift to pass through the jetty, causing shoaling of the inner bar and the Sand Island and Crossover Channel. The deterioration of the jetty also forced the channel southward from 2,000 ft north of the south jetty to along the north side of the south jetty. The channel gradually deepened, reaching depths of -65 to -70 ft mllw and eroding the sand foundation material from the south jetty.

124. In 1966 4,000 ft of the south jetty were reconstructed, and 6,000 ft of the north jetty were reconstructed during 1975 to 1976, both using placed stone construction over the earlier randomly placed stone. The outer 5,600 ft of the south jetty and 1,200 ft of the north jetty are submerged, and there are no plans to restore them to grade. The reconstructed portion of the north jetty has been overtopped on several occasions, threatening or damaging a major roadway that parallels a portion of the jetty.

125. The jetties were inadequate to maintain project dimensions in the bar channel, particularly when in a deteriorated condition. Supplemental dredging was therefore initiated in 1916 and continued at regular intervals until 1926. The bar required almost continual dredging from 1926 until the jetties were reconstructed. The bar has not been dredged since 1942. A chronology of events related to the development and repair of the harbor structures is given in Table 37.

Kingston Harbor, Washington

126. Kingston Harbor is a locally maintained small-boat basin located in Appletree Cove on Puget Sound at Kingston, Washington, about 10 miles northwest of Seattle. The project authorized improvements to an existing basin, including construction of a 1,040-ft rubble-mound breakwater and dredging an entrance channel. The project was adopted in 1962 and constructed in 1967. No problems or repairs have been reported. A chronology of events related to the development and repair of the harbor structures is given in Table 38.

Lake Crockett, Washington

127. Lake Crockett is located on Whidbey Island, Washington, along Admiralty Bay in Puget Sound. The project includes a 6-acre mooring basin protected by a breakwater.

128. The project was adopted in 1945, providing for a mooring basin and an entrance channel connecting the basin to Admiralty Bay, protected by a rubble-mound breakwater. The project was completed in 1948.

129. The breakwater required repairs in 1950 and 1954 then was restored to its design height in 1960. In addition, the breakwater was extended 175 ft northerly, and a 90-ft easterly spur was added to provide additional protection against southeasterly storms. In 1971 the channel was widened to 200 ft to reduce the frequency of dredging. A chronology of events related to the development and repair of the harbor structures is given in Table 39.

Neah Bay, Washington

130. Neah Bay is located on the Strait of Juan de Fuca about 5 miles east of Cape Flattery at the northwest tip of the State of Washington. The project includes an 8,000-ft rubble-mound breakwater extending from the west side of Neah Bay to Waada Island and a revetment extending west from Baada Point for 3,000 ft.

131. The breakwater was authorized in 1938 and constructed during 1941 to 1944. The breakwater was repeatedly damaged by displacement of armor stone during winter storms, and by 1949 it had been breached in about ten places. The breakwater was restored in 1949 and again in 1959. By 1978 the breakwater had again been breached in 10 to 12 places. The westerly 4,200 ft of the breakwater were rehabilitated in 1980.

132. Construction of the breakwater resulted in sustained erosion of material from the beach west of Baada Point. The Crown-Zellerbach Corp., the US Coast Guard, and the Indian Agency, therefore, constructed a 2,200-ft revetment to protect the shoreline. In 1956, the Corps of Engineers reinforced the existing revetment and extended it 800 ft westerly.

133. The breakwater and revetment appear in good condition at this time. A chronology of events related to the development and repair of the harbor structures is given in Table 40.

Olympia Harbor, Washington

134. East Bay Marina is located in Olympia Harbor at the southern end of Puget Sound, about 62 miles south of Seattle, Washington. The project includes a marina, an entrance channel, two access channels, and a 656-ft long floating breakwater.

135. Construction of the breakwater was completed in 1983. The breakwater is a floating concrete structure consisting of seven hollow rectangular modules 16 ft wide by 5.5 ft deep. The breakwater includes mooring facilities on the marina side, fenders to protect the moored vessels, and access from shore. No repairs or structural problems have been reported. A chronology of

events related to the development and repair of the harbor structures is given in Table 41.

Port Angeles Harbor, Washington

136. Port Angeles is located on the northern Washington coast along the Strait of Juan de Fuca. The project includes expansion of a small-boat basin and construction of a 1,000-ft breakwater and a 170-ft entrance breakwater. The main breakwater is of rock-reinforced treated timber pile and planking construction. The original breakwater design called for all stone construction. Pressure from local interests to expedite the project resulted in the design modification to timber and stone construction, with the agreement that the locals would be responsible for maintenance once the structure was completed.

137. The expansion of the boat basin and construction of the breakwaters were authorized in 1945. The project had authorized removal of a 150-ft length of a shoal in the harbor. This was not done, and the shoal removal was deauthorized in 1977.

138. The harbor is protected by Ediz Hook, a narrow spit extending about 3-1/2 miles into the Strait of Juan de Fuca and forming the north and westerly sides of the harbor. Erosion of the spit has been a problem since about 1910 when various bulkhead erosion control structures further up the coast interfered with the littoral drift. Local interest construction of erosion control measures began in the 1930's but were piecemeal and generally ineffective.

139. The Corps project on Ediz Hook was adopted in 1974 and completed in 1978. The project includes a 13,300-ft-long revetment, a 3,100-ft-long rock blanket (later upgraded to revetment), beach nourishment, and anticipated additional beach nourishment at 5-year intervals. The structures have suffered localized damage, runup and overtopping, and toe instability. A chronology of events related to the development and repair of the harbor structures is given in Table 42.

Port Townsend Small-
Boat Basin, Washington

140. Port Townsend is located on the northern Washington coast at the junction of Admiralty Inlet and the Strait of Juan de Fuca. The small-boat harbor consists of two adjacent basins. The original basin was locally constructed, covers about 3 acres, and is protected by a 1,150-ft rubble-mound

breakwater. The Corp's project added an adjacent 12.5-acre basin, a 1,946-ft rubble-mound breakwater, and a channel through the original breakwater to provide access to the second basin. The Corps is responsible for maintaining the Corps constructed breakwater, the mooring basin, and the entrance channel. A chronology of events related to the development and repair of the harbor structures is given in Table 43.

Quillayute River Boat
Basin, Washington

141. The Quillayute River project is located on the Washington coast at the town of La Push. The project includes a small-boat basin with a timber training wall on one side and timber breakwaters at each end; a 1,400-ft-long rubble-mound breakwater along the east side of the river's mouth, crest elevation of +15 to +18 ft mllw with a crest width of 18 ft; a 1,050-ft-long rubble-mound dike along the west side of the river between Quillayute Spit and James Island, crest elevation of +8 ft mllw with a crest width of 6 ft; a navigation channel extending from deep water to the small-boat basin; an additional channel extending to the mouth of Smith Slough; and maintenance of Quillayute Spit, a natural spit about 3,400 ft long.

142. The project was authorized in 1930 and constructed in 1931. The jetty and dike were damaged by winter storms and repaired in 1932, 1941, 1946, 1949, 1953, and 1956. In 1956 the Corps assumed responsibility for repairing the spit. The boat basin was dredged in 1957. The jetty was raised in 1957 and again in 1960.

143. The dredged material was deposited on the spit. In 1973 the material dredged from the river was too fine for replenishing the spit, and serious erosion problems developed. A rock blanket covering the spit was recommended. The blanket, with a 10-year life expectancy, was installed in 1974 and replaced in 1978. The spit was breached in 1979 and 1981.

144. In 1982 major rehabilitation of the project was recommended. A chronology of events related to the development and repair of the harbor structures is given in Table 44.

Shilshole Bay, Washington

145. Shilshole Bay is on the eastern shore of Puget Sound at Seattle, Washington and at the entrance to the Lake Washington Canal. The project includes a 4,200-ft-long rubble-mound breakwater with a crest height of +20 ft mllw, a 240-ft-long rubble-mound extension at the north end of the breakwater

with a crest height of +16 ft mllw, and a 72.8-acre small-boat basin behind the breakwater. A chronology of events related to the development and repair of the harbor structures is given in Table 45.

Swinomish Channel, Washington

146. Swinomish Channel is a dredged inland tidal waterway--100 ft wide, -12 ft mllw deep, and 11 miles long--located in the northwestern part of the state of Washington about 60 miles north of Seattle. It connects the deep waters of Saratoga Passage and Padilla Bay and separates Fidalgo Island from the mainland. The project includes dikes along the waterway to protect farmland and three jetties at the southern end of the channel.

147. The project was adopted in 1892. The jetties include a rubble-mound and timber pile north jetty extending west from "Hole in the Wall," a rubble-mound south jetty extending west from Goat Island, and a rubble-mound jetty connecting Goat Island to McGlinn Island. The north jetty was constructed in 1893 and reconstructed in 1900. The south jetty was constructed in 1908 and rehabilitated and extended in 1973. The Goat-McGlinn Island jetty was completed in 1938 and rehabilitated in 1940, 1946, and 1963.

148. The rehabilitations were required because of settlement due to foundation problems. At the present time, the south jetty and the Goat-McGlinn Island jetty appear to be in good condition, while the north jetty shows obvious deterioration. A chronology of events related to the development and repair of the jetty structures is given in Table 46.

Waterway Connecting Port Townsend and Oak Bay, Washington

149. Port Townsend is located on the northern Washington coast along the Strait of Juan de Fuca. The Oak Bay Canal connects Port Townsend Bay and Oak Bay. The project includes two jetties at the Oak Bay end of the canal, the west jetty being 550 ft long and the east jetty being 600 ft long, and 2,100 ft of bulkheads on the west side of the canal. The jetties were constructed of brush, pile, and stone; the bulkheads were constructed of brush, pile, and timber.

150. The project was adopted in 1913 and completed in 1916. The east jetty was rehabilitated in 1937; the west jetty was rehabilitated in 1961. Very little information on the project is available. Currently, the west jetty is in good condition, while the east jetty shows some deterioration but is stable and functional. A chronology of events related to the development

and repair of the jetty structures is given in Table 47.

Westhaven Cove Small-
Boat Basin, Washington

151. Westhaven Cove is located on Gray's Harbor on the Pacific Coast of Washington, about 100 miles north of Portland, Oregon. The basin, referred to as West Port Marina, is protected by three main breakwaters (breakwaters A, B, and C), a closure breakwater, a breakwater that existed before the Corps assumed the project, and a stub breakwater. In addition, the Corps maintains a groin field and revetment at the tip of Point Chehalis.

152. Breakwater A is connected to the north end of the basin and is 970 ft long. Breakwater B, 700 ft long, was detached and located near the end of breakwater A. A closure breakwater, 260 ft long, connects the two breakwaters. Breakwater C, 1,550 ft long, is connected to a detached 865-ft breakwater at the southern end of the basin that existed before the Corps takeover of the project. The stub breakwater is 200 ft long and extends from the south end of the marina toward the detached breakwater. All of the breakwaters are of stone and timber composite construction.

153. Reconstruction of the south jetty at Gray's Harbor, Washington, during 1936 to 1939 blocked the littoral drift feeding Point Chehalis, resulting in extensive erosion. A short section of the south jetty was removed to try to restore the littoral transport, but the opening was quickly blocked with sand. A groin field was therefore constructed on the point to trap sediment, and a revetment was constructed to protect the shoreline. A chronology of events related to the development and repair of the harbor structures is given in Table 48.

Willapa River and Harbor and
Naselle Harbor, Washington

154. Nahcotta is located on the west side of Willapa Bay on the Pacific coast of Washington. The project includes an entrance channel to a mooring basin and a rubble-mound breakwater about 1,500 ft long. There have been no structural problems reported since completion of the breakwater in 1958.

155. The project is part of the Willapa River and Harbor project adopted in 1916 and modified by subsequent Acts. The project includes 26 miles of deep-draft channels which were classified "inactive" in 1977. A chronology of events related to the development and repair of the harbor structures is given in Table 49.

Table 1

Cordova Small-Boat Harbor

Cordova, Alaska

Date(s)	Construction and Rehabilitation History
1935	The small-boat basin was authorized.
1938	The project was completed, including 8.26 acres dredged to -10 ft mllw; and a 1,100-ft north breakwater and a 1,400-ft south breakwater were constructed.
1964	The area was uplifted 6.4 ft in an earthquake. Expansion was authorized.
1964-1965	The basin was rehabilitated by repairing and strengthening breakwaters, constructing an access road along the crest of the north breakwater, and dredging the basin plus an additional 10.4 acres to -14 ft mllw.
1966	An entrance breakwater was constructed. The harbor at this stage is shown in Figure 4.
1981	Expansion was authorized.
1981-1983	The basin was expanded by 19.55 acres by removal of the 1,400-ft south breakwater, construction of a 650-ft extension to the existing silt barrier breakwater, and construction of a 1,902-ft rubble-mound breakwater. A rubble-mound breakwater was constructed to crest elevation of +21.5 ft mllw, crest width of 7 ft, and side slopes of 1:1.5. The breakwater was constructed of a 2-ft-thick bedding layer of rock spall, a core of Class "B" rock, and a 4.5-ft-thick layer of Class "A" armor rock extending to 1.5 wave heights below low tide on the north section of the breakwater and to the tidal flats on the other sections. The silt barrier breakwater was constructed of a 2-ft-thick underlayer of rock spall, a core of rock spall, and a protective layer of Class "B" rock. Cross sections of the breakwaters are shown in Figure 5. The basin extension was dredged by local interests to -12 to -16 ft mllw; the Corps deepened the entrance channel to -16 ft mllw. The design wave was 5.6 ft. Class "A" armor rock was 900 to 1,500 lb with 75 percent greater than 1,200 lb. Class "B" rock was 14 to 1,000 lb with 50 percent greater than 100 lb. Rock spall was 6 in. minus.
1985	The harbor is illustrated in Figure 5, and an aerial photograph of the harbor is presented in Figure 6. The breakwaters appear in good condition at this time.

Figure 4. Aerial photograph of Cordova Harbor, Alaska, 1977

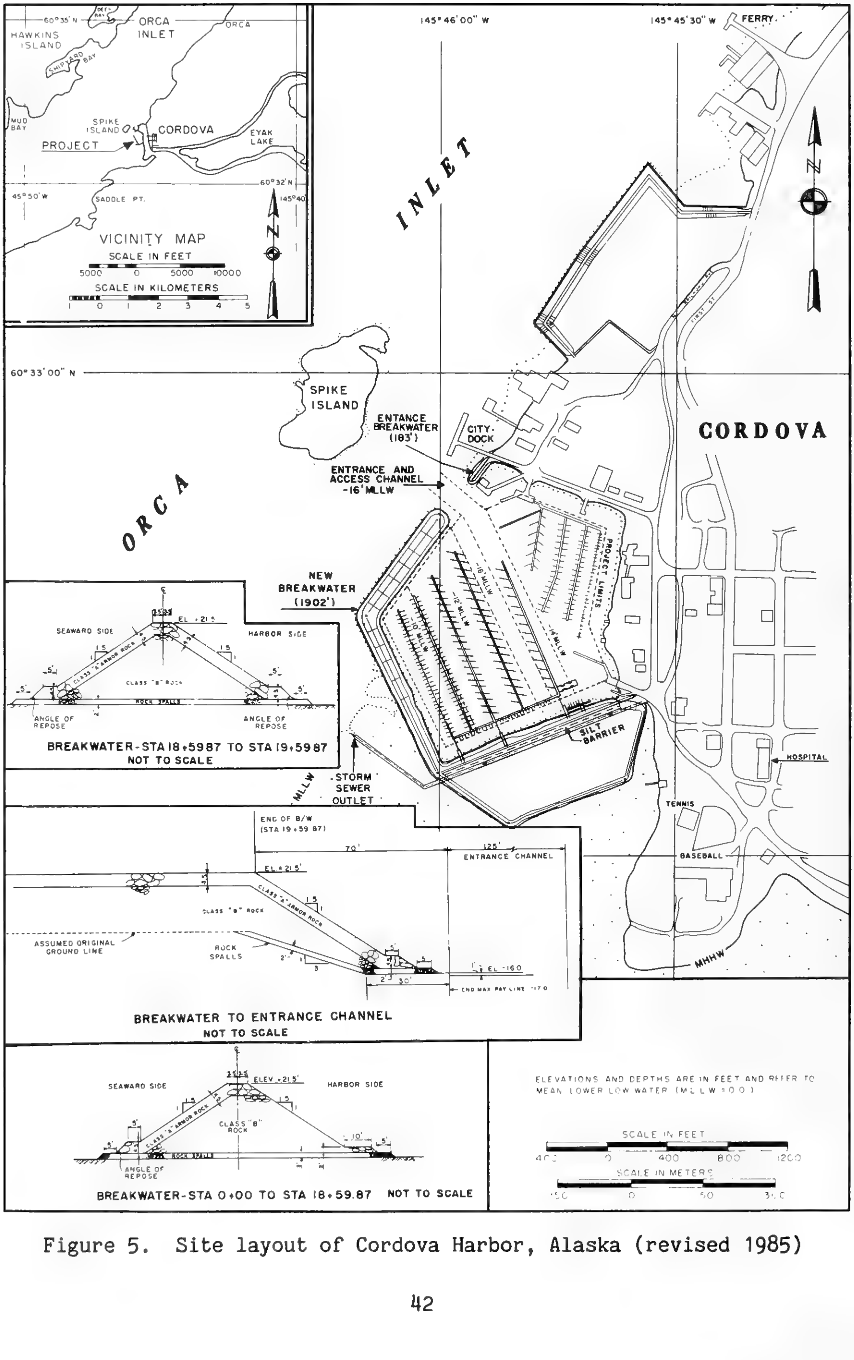

Figure 5. Site layout of Cordova Harbor, Alaska (revised 1985)

Figure 6. Aerial photograph of Cordova Harbor, Alaska, 1984

Table 2

Craig Harbor

Craig, Alaska

Date(s)	Construction and Rehabilitation History
1945	The project was adopted, including a dredged mooring basin in South Cove.
1975	The floating dock system was expanded by local interests.
1977	A storm damaged vessels in the expanded portion of the floating dock system.
1981-1983	Two breakwaters were constructed to protect the expanded area of the dock system. The north breakwater was 160 ft long, and the south breakwater was 300 ft long. Both breakwaters were constructed to a crest elevation of +20 ft mllw, a crest width of 8 ft, and 1:1.5 side slopes. The breakwaters were constructed with a core of quarry-run rock covered by a filter layer of 150- to 1,500-lb rock, and an armor layer of 2,200-lb rock with a range of 1,500 to 3,000 lb. The breakwater was designed for a significant wave height of 5.3 ft; the armor rock was designed for the 10 percent wave height of 6.7 ft.
1985	The harbor is illustrated in Figure 7, and an aerial photograph of the harbor is presented in Figure 8. There are no reports of needed repairs or rehabilitation.

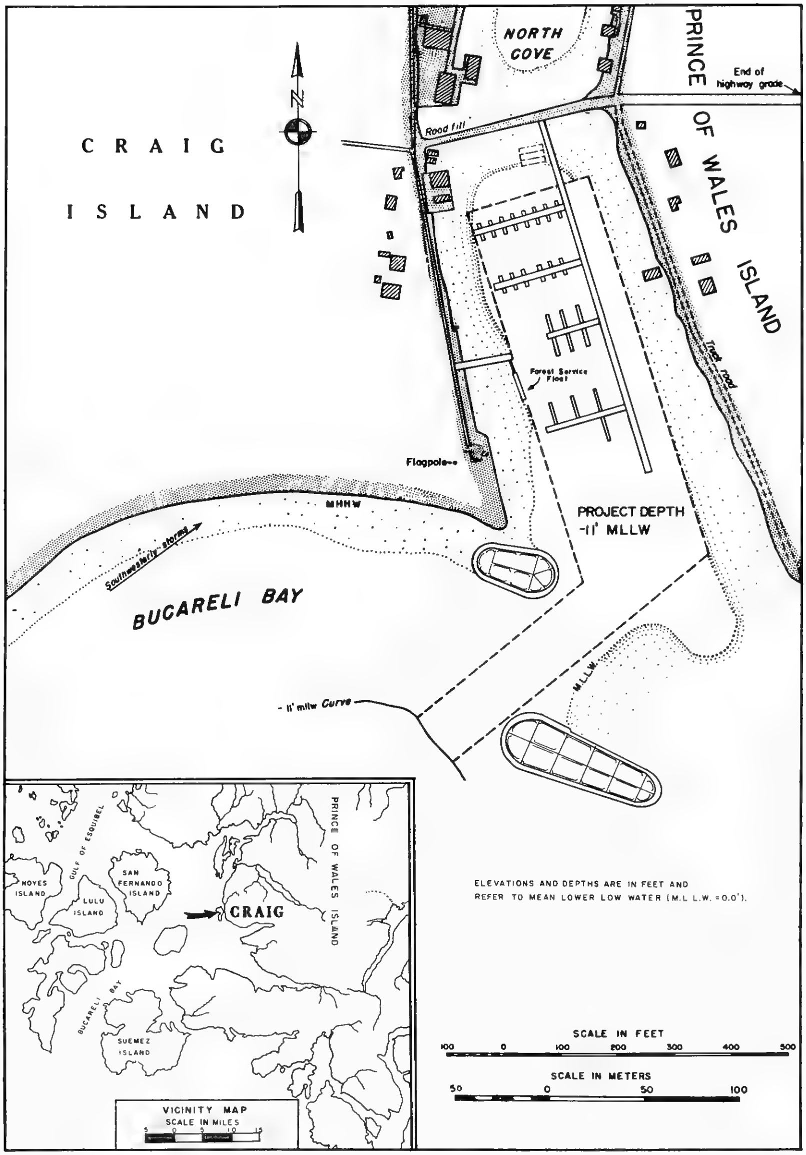

Figure 7. Site layout of Craig Harbor, Alaska (revised 1985)

Figure 8. Aerial photograph of Craig Harbor, Alaska, 1984

Table 3

Douglas Small-Boat Basin

Douglas, Alaska

Date(s)	Construction and Rehabilitation History
1958	The project was adopted, including a 5.2-acre basin and a 90-ft rubble-mound breakwater.
1962	The project was completed, including a 5.2-acre basin and a 105-ft rubble-mound breakwater. The breakwater was constructed to crest elevation of +24 ft mllw, crest width of 6 ft, and side slopes of 1:1.5. Core material was 3,548 cu yd of quarry-run rock. The armor layer had a 4-ft thickness of 175- to 275-lb armor rock, with 50 percent greater than 225 lb. The armor layer extended to the toe of the breakwater and included the harbor side, requiring 1,203 cu yd of rock. The design wave was 2.4 ft and 2.6 sec.
1985	The harbor is illustrated in Figure 9, and an aerial photograph of the harbor is presented in Figure 10. There are no reports of needed repairs or rehabilitation.

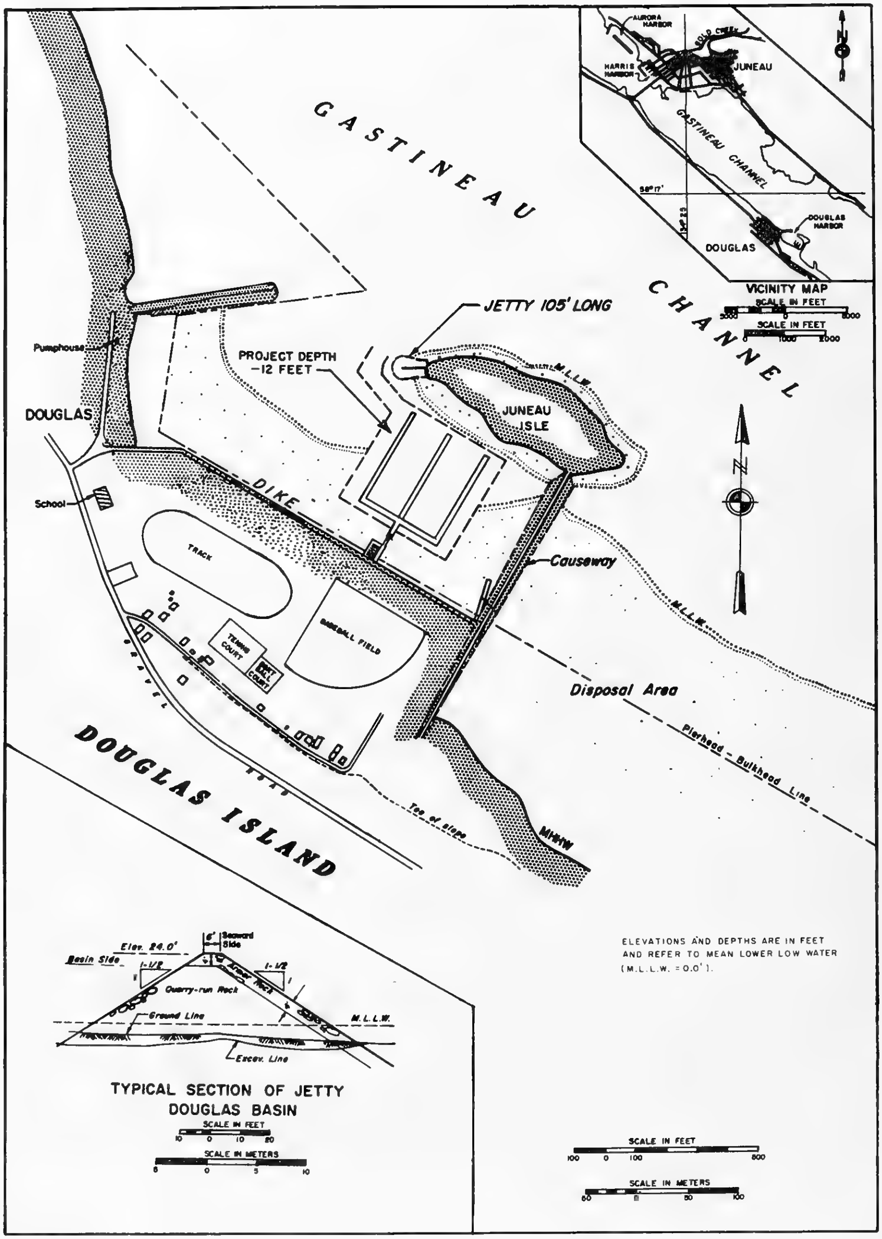

Figure 9. Site layout of Douglas Harbor, Alaska (revised 1978)

Figure 10. Aerial photograph of Douglas Harbor, Alaska, 1984

Table 4

Haines Small-Boat Basin

Haines, Alaska

Date(s)	Construction and Rehabilitation History
1958	The original breakwater was constructed.
1971	The project was adopted.
1976	The project was completed, including a 4.2-acre boat basin dredged by local interests to -12 ft and -15 ft mllw, and an entrance channel maintained by the Corps to -15 ft mllw. The seaward leg of the existing breakwater was removed, and a 905-ft crescent-shaped offshore breakwater was constructed. The crest elevation on the new breakwater was +26 ft mllw, the crest width was 4 ft, and side slopes were 1:2 on the seaward side and 1:1.5 on the harbor side. The breakwater was constructed with a rubble core covered by armor rock. The crest width and outer face of the trunk were covered with 2.5 ft of 300-lb rock. Armor on the ends and first and last 100 ft of the trunk consisted of 3 ft of 400-lb rock. The remainder of the inner face was covered with three ft of 40-lb rock. A gap was left between the offshore breakwater and the older breakwater to protect salmon fry and promote circulation in the basin.
1985	The harbor is illustrated in Figure 11, and an aerial photograph of the harbor is presented in Figure 12. There are no reports of needed repairs or rehabilitation.

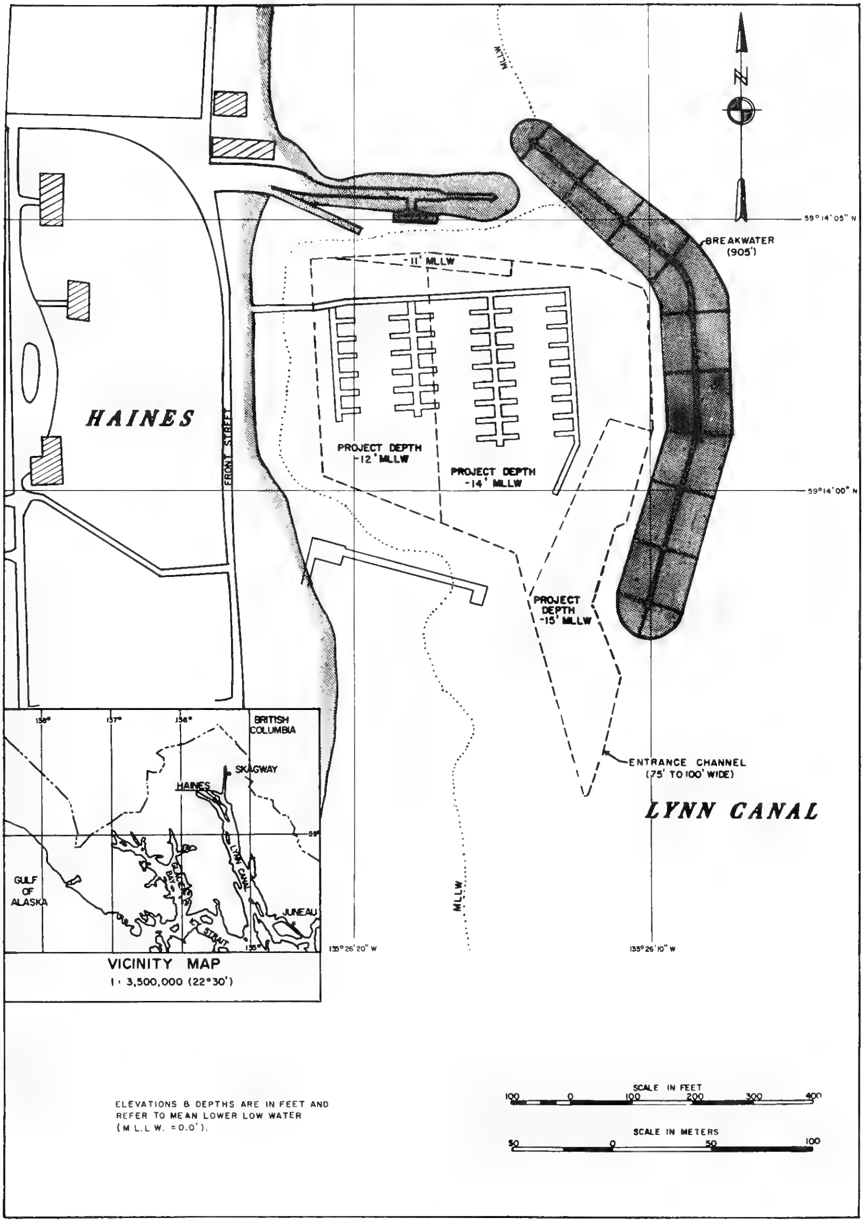

Figure 11. Site layout for Haines Harbor, Alaska (revised 1981)

Figure 12. Aerial photograph of Haines Harbor, Alaska, 1980

Table 5

Homer Harbor

Homer, Alaska

Date(s)	Construction and Rehabilitation History
1958	The original harbor plan was adopted.
1962	The original harbor was completed, including a 180- by 672-ft basin (2.8 acres), and a 1,260-ft rubble-mound breakwater.
1964	The original harbor was destroyed by earthquake, and the breakwater was severely damaged.
1965	The harbor was restored and relocated slightly to the northwest. The restored harbor included 2.75 acres at -12 ft mllw and 7.25 acres at -15 ft mllw, protected by a 1,018-ft main breakwater and a 238-ft entrance breakwater. Both breakwaters were constructed of a quarry-run core covered with an armor layer to crest elevation of +29 ft mllw with 1:1.5 side slopes. The main breakwater had a 7-ft crest width and was covered with a 5.5-ft layer of armor rock. The entrance breakwater had a 9-ft crest width and was covered with a 5.5-ft layer of armor rock on the entrance side and a 3-ft layer on the seaward side. The main breakwater had a rock blanket 3 ft thick extending 10 ft past the toe on the entrance side. The entrance breakwater had a 3-ft-thick rock blanket extending 10 ft past the toe on the seaward side. Armor rock was 700 to 1,100 lb. The entrance channel was dredged to -15 ft mllw and 120 ft wide at project depth, with 1:3 side slopes protected by a 1.5-ft-thick rock blanket. Cross sections of the breakwaters are shown in Figure 13.
1968-1970	The basin was expanded to 16.5 acres by local interests by extending basin and protective berm 700 ft to the northwest. The harbor is illustrated in Figure 13, and an aerial photograph of the harbor is presented in Figure 14.
1984-1985	The project was expanded to 50 acres by extending the basin 1,040 ft to the southwest and 350 ft to the northeast, yielding a 3,000- by 750-ft harbor. The basin was protected by a rubble-mound berm on the northeast with a 220-ft crest width providing 2-lane vehicular access. The berm had a top elevation of +31 ft mllw with 1:6 side slopes on the seaward side and 1:3 side slopes on the basin side. The harbor at this stage is illustrated in Figure 15. The main breakwater was removed from the expanded harbor and west of the entrance and replaced with a breakwater with crest elevation at +31 ft mllw, crest width of 220 ft, and side slopes of 1:2 on the seaward side and 1:3 on the basin side. The dredged core was covered on the seaward side by a 1-ft gravel layer (12-in. minus), a 3-ft layer of secondary armor rock (Class "B", 100 to 1,100 lb,

(Continued)

Table 5 (Concluded)

Date(s)	Construction and Rehabilitation History
	15 percent less than 250 lb), and a 4.5-ft layer of primary armor rock (Class "A", 1,100 to 3,000 lb, 50 percent between 1,500 and 1,900 lb).
1985	The breakwaters are in good condition at this time.

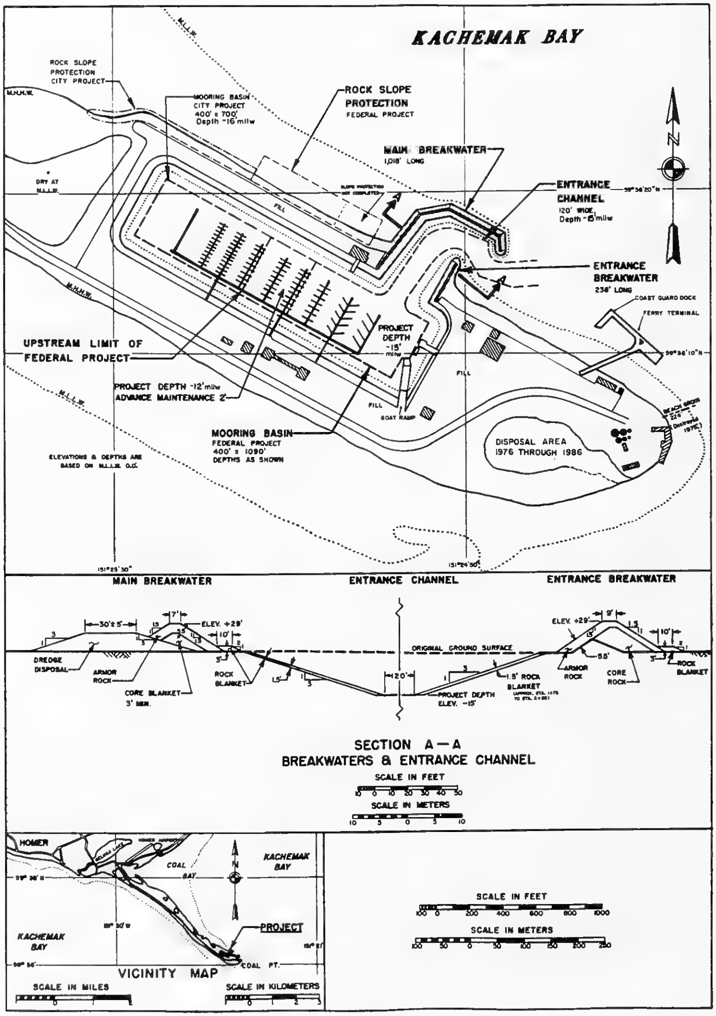

Figure 13. Site layout of Homer Harbor prior to expansion during 1984-1985 (revised 1978)

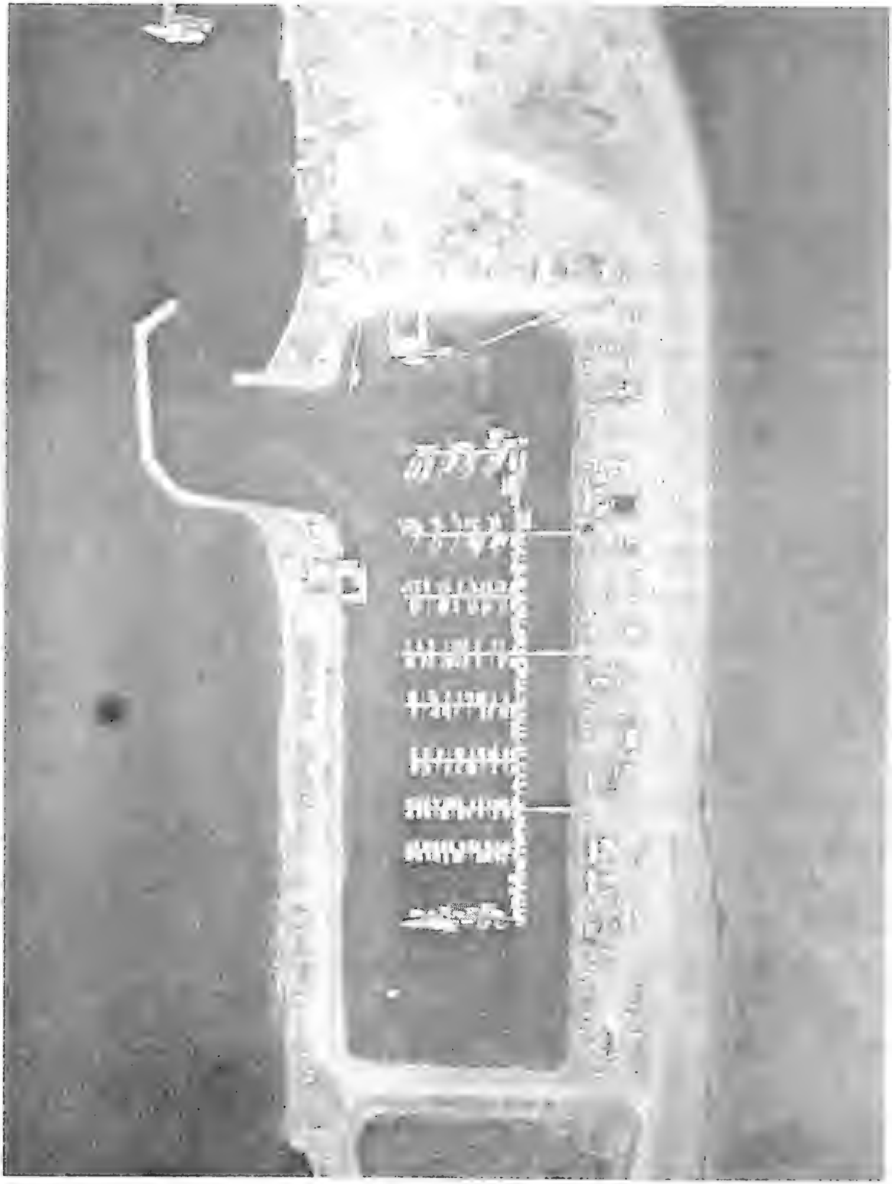

Figure 14. Aerial photograph of Homer Harbor, Alaska, 1977

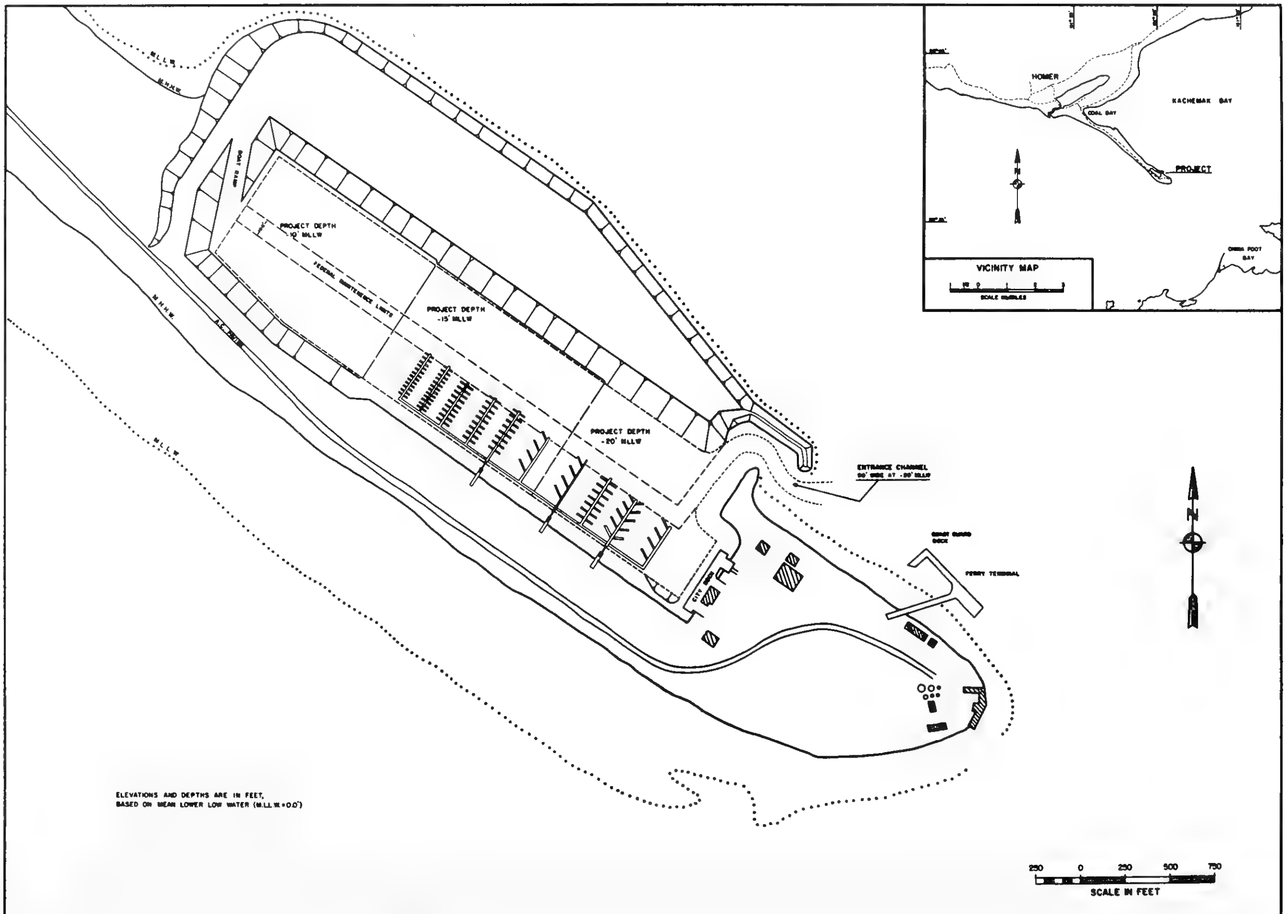

Figure 15. Site layout of Homer Harbor, Alaska, after expansion during 1984-1985 (revised 1985)

Table 6

Hoonah Harbor

Hoonah, Alaska

Date(s)	Construction and Rehabilitation History
1972	The project was adopted.
1979-1980	The project was constructed, including a 15.5-acre boat basin, three rubble-mound breakwaters, and two rubble-mound diversion dikes. The main breakwaters were 800 ft and 1,507 ft long, and an entrance breakwater was 140 ft long. The breakwaters were constructed to a crest elevation of +24 ft mllw, crest width of 4.5 ft, and side slopes of 1:1.5. The 4-ft-thick layer of armor rock, 470 to 780 lb, covered a core of quarry spalls. The armor rock extended from the crest to -12 ft mllw on the seaward side and for 150 ft back from the head on the basin side, and to +15 ft mllw over the rest of the breakwater on the basin side. The diversion dikes were constructed of dredged material covered with a 1-ft filter layer and a 3-ft layer of rock spalls. The main purpose of the diversion dikes was to prevent ice from entering the basin. Crest elevations were +24 ft mllw for the south dike and +21 ft mllw for the east dike. A gap was left between the dikes for circulation in the basin and protection of salmon fry. Design was based on a 10 percent wave of 4.6 ft, nonbreaking. The harbor is illustrated in Figure 16; cross sections of the breakwaters are given in Figure 17.
1985	An aerial photograph of the harbor is presented in Figure 18. There are no reports of needed repairs or rehabilitation.

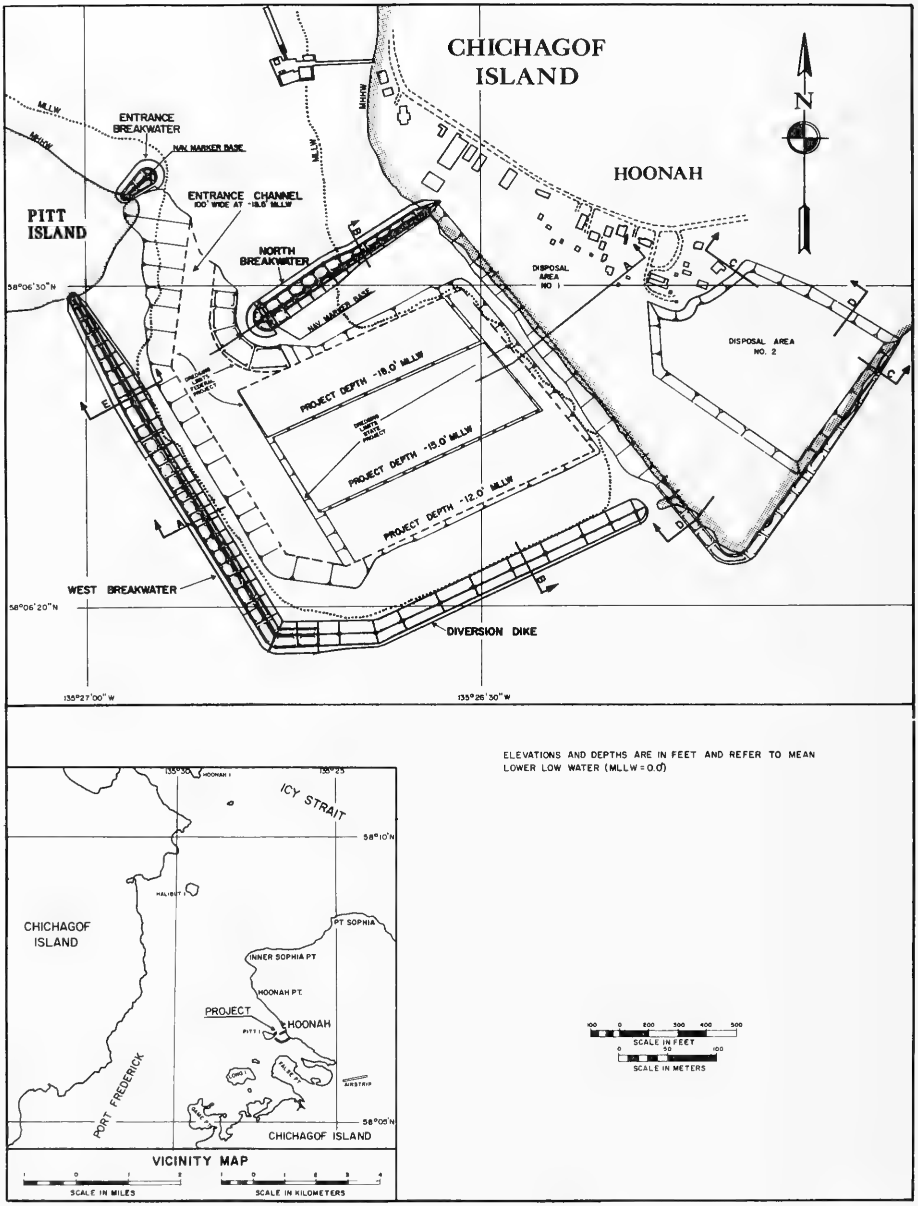

Figure 16. Site layout of Hoonah Harbor, Alaska (revised 1981)

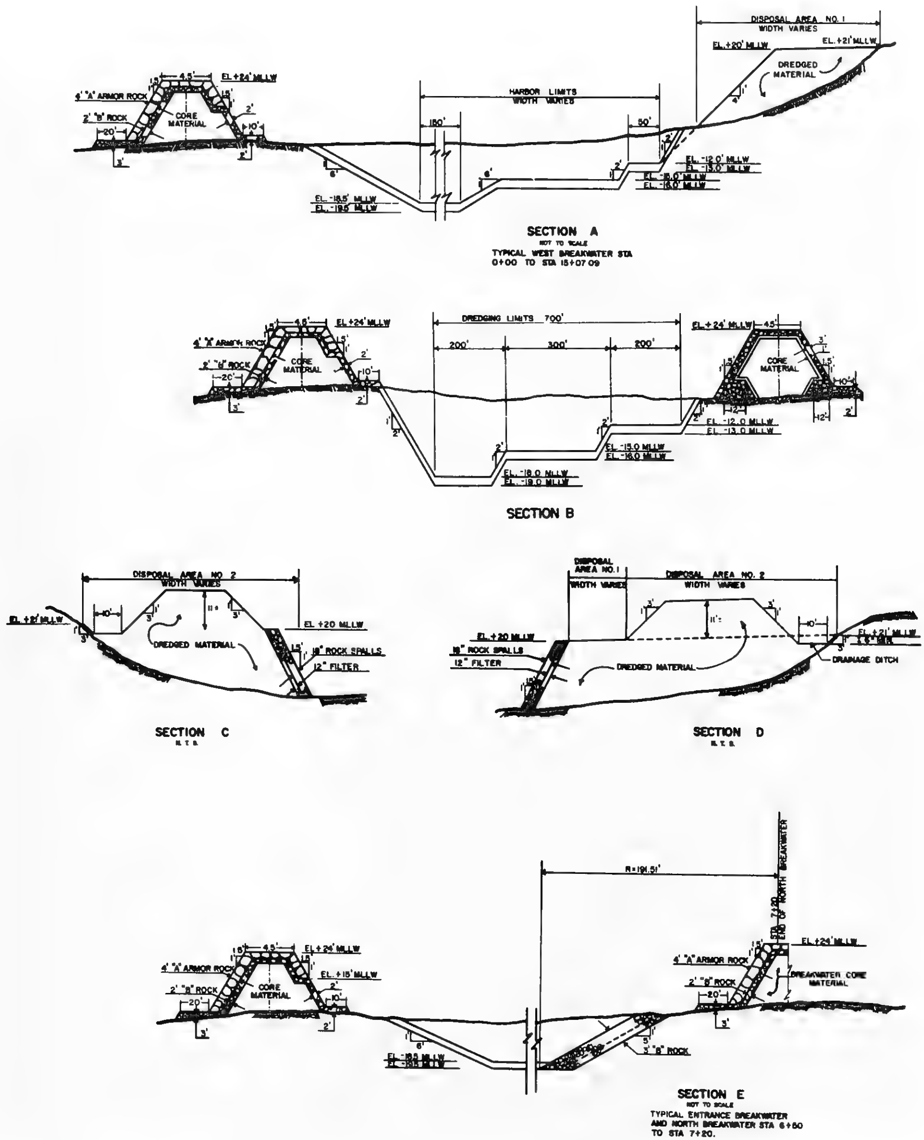

Figure 17. Cross sections of breakwaters at Hoonah Harbor, Alaska (revised 1980)

Figure 18. Aerial photograph of Hoonah Harbor, Alaska, 1984

Table 7

Humboldt Harbor

Sand Point, Alaska

Date(s)	Construction and Rehabilitation History
1970	The project was adopted.
1975-1976	The project was constructed, including a 16.6-acre mooring basin protected by two rubble-mound breakwaters and a rubble-mound diversion dike. The 1,025-ft north breakwater was constructed to a crest elevation of +15 ft mllw, crest width of 6 ft, and side slopes of 1:1.5 on the basin side and 1:2 on the seaward side. The 740-ft south breakwater was of similar construction but with a crest elevation of +13 ft mllw. The breakwaters were constructed of core material covered with a 4.5-ft layer of secondary armor rock (50 to 500 lb, 130-lb average) or a 2-ft layer of secondary armor rock under a 4-ft layer of primary armor rock (1,000 to 4,000 lb, 1,300-lb average). The primary armor covered the seaward side of the breakwaters and 150 ft from the heads on the basin sides to -13 ft mllw. It also covered the remainder of the basin sides to -3.5 ft mllw. The 1,175-ft diversion dike was constructed to a crest elevation of +12 ft mllw, crest width of 8 ft, and 1:2 side slopes. The core material was covered with a 1-ft filter layer and a 3-ft layer of quarry spalls. The entrance channel was dredged to -18 ft mllw with a minimum width of 120 ft.
1985	The harbor is illustrated in Figure 19, and an aerial photograph of the harbor is presented in Figure 20. There are no reports of needed repairs or rehabilitation.

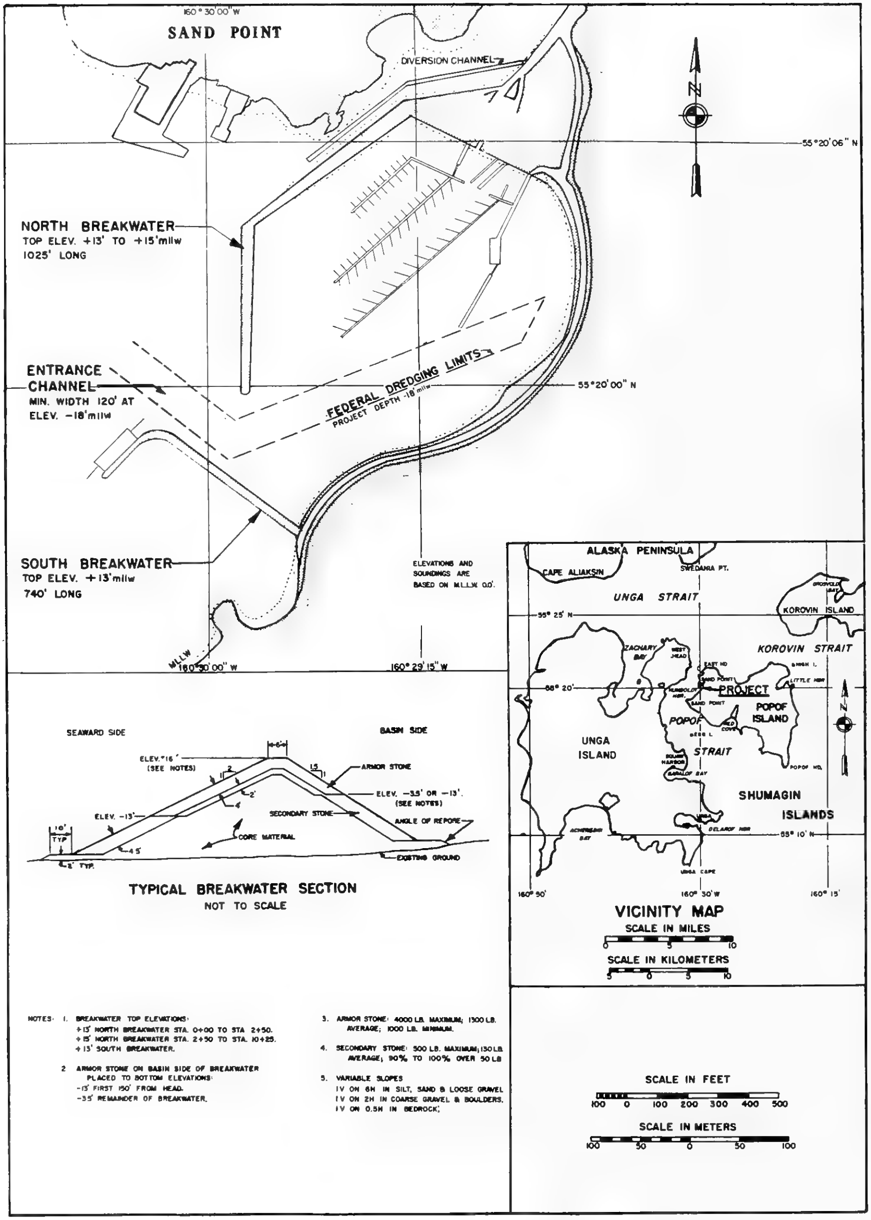

Figure 19. Site layout of Humboldt Harbor, Alaska (revised 1984)

Figure 20. Aerial photograph of Humboldt Harbor, Alaska, 1984

Table 8

Juneau Harbor

Juneau, Alaska

Date(s)	Construction and Rehabilitation History
	Harris Basin
1937	The project was adopted.
1938-1939	The breakwaters were constructed. The 430-ft south breakwater was constructed as a rock mound to elevation +24 ft mllw, crest width of 8 ft, and 1:1.5 side slopes. The 1,540-ft north breakwater was constructed to an elevation of +26 ft mllw, a crest width of 8 ft, and side slopes of 1:1.5. The north breakwater was constructed of rubble mound covered with a 2-ft-thick layer of Class "A" armor rock on the crest and on the channel side to elevation -10 ft mllw. The breakwaters required 77,349 cu yd of rock. Breakwater cross sections are given in Figure 21.
1939	An 11.5-acre basin was dredged to -12 ft mllw.
1973	The north breakwater was repaired by reshaping and placing armor stone.
1985	The harbor is illustrated in Figure 21, and an aerial photograph of the harbor is presented in Figure 22. There have been no reports of needed repairs or rehabilitation since 1973.
	Aurora Basin
1958	The project was adopted, including a 19-acre basin protected by a 530-ft jetty and a 1,150-ft breakwater. During the design stage, the jetty and breakwater were lengthened to 670 ft and 1,500 ft, respectively. The breakwater was originally designed as a rubble mound, but the design was changed to a composite rubble-mound plank and piling breakwater due to unstable soil conditions.
1962	The jetty was constructed of rubble mound to elevation +24 ft mllw, with a crest width of 4 ft, and side slopes of 1:1.5. The jetty required 24,000 tons of rock. Jetty cross sections are shown in Figure 21.
1962-1963	The 19-acre basin was dredged, 13.1 acres to -12 ft mllw and 5.9 acres to -14 ft mllw.
1963-1964	The main breakwater was constructed of a rubble mound to elevation +12 ft mllw and steel pilings with treated planks to elevation +24 ft mllw. The rubble mound included a dredged material blanket 90 ft wide and 1,500 ft long, a core of dredged material to elevation

(Continued)

Table 8 (Concluded)

Date(s)	Construction and Rehabilitation History
	+1.5 ft mllw, and a layer of quarry rock with 50 percent weight of 15 to 500 lb. The quarry rock was covered with a 2-ft-thick layer of armor rock on the crest, channel side, and around the ends, and a 1.5-ft-thick layer of armor rock on the basin side. The armor rock had a 50 percent weight of 40 to 500 lb, with a maximum of 1,000 lb. The rubble mound had a crest width of 4 ft and 1:1.5 side slopes. The rubble mound was placed after the steel pilings were driven to 24-ft penetration. The pilings were driven on 6-ft centers and covered with 3- by 12-in. creosote-treated planks. The planks required a 2-in. thickness to prevent damage from wave action, but 3-in. thickness was used to prevent damage from boats. The maximum expected wind-generated wave was 1.7 ft, the maximum expected boat wake was 2 ft; therefore the design wave was a 2-ft, nonbreaking, short-period wave. The breakwater required 30,450 cu yd of rock and 8,820 linear ft of steel piles. Breakwater cross sections are shown in Figure 21.
1985	The harbor is illustrated in Figure 21, and an aerial photograph of the harbor is presented in Figure 23. There have been no reports of needed repairs or rehabilitation since 1973.

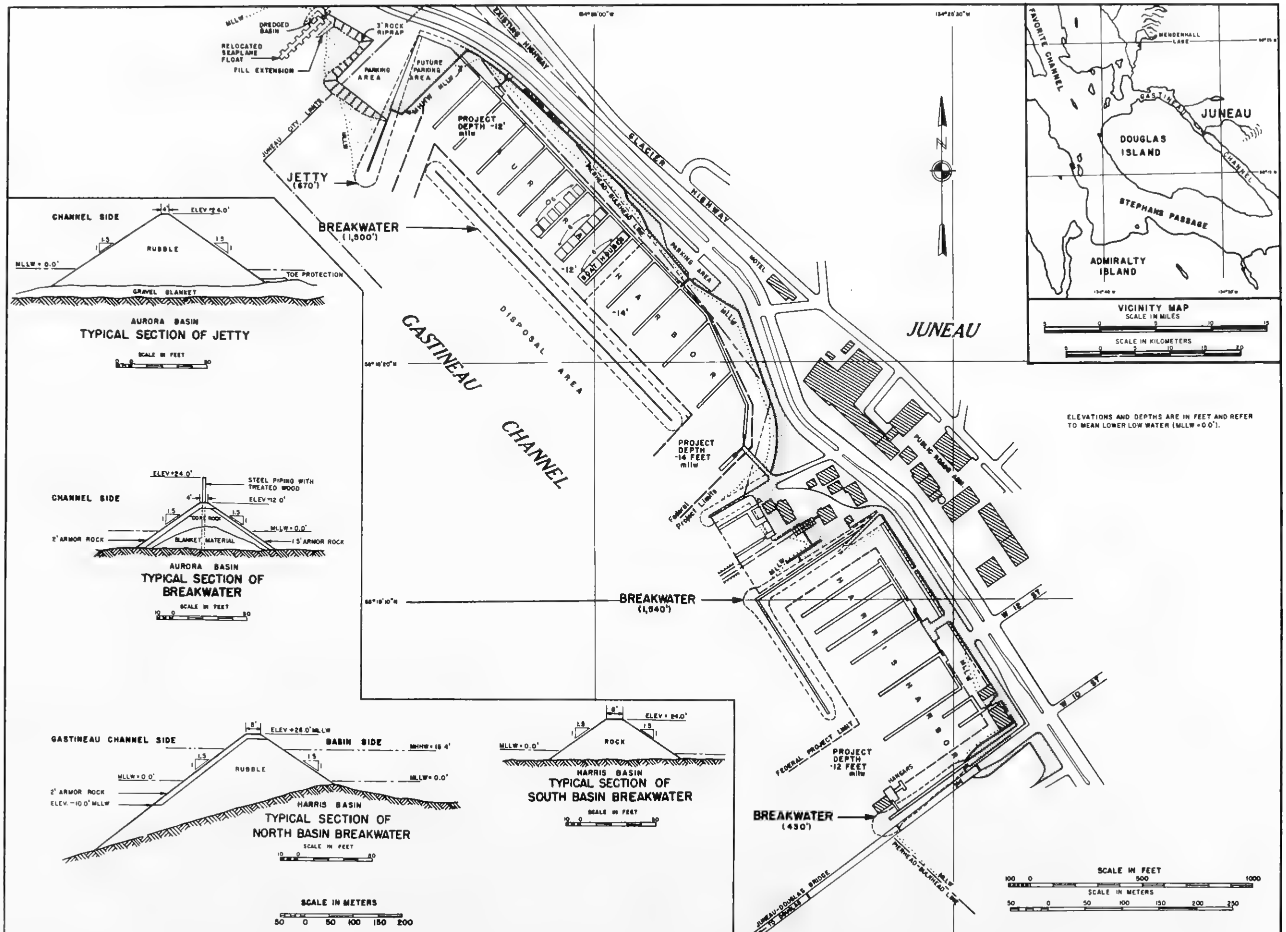

Figure 21. Site layout of Harris and Aurora Basins, Juneau Harbor, Juneau, Alaska (revised 1981)

Figure 22. Aerial photograph of Harris Basin, Juneau Harbor, Alaska, 1984

Figure 23. Aerial photograph of Aurora Basin, Juneau Harbor, Alaska, 1984

Table 9

Ketchikan Harbor

Ketchikan, Alaska

Date(s)	Construction and Rehabilitation History
	Thomas Basin
1930	The project was adopted.
1932	The project was completed, including dredging an 11.35-acre basin to -10 ft mllw and constructing a 940-ft stone breakwater to an elevation of +20 ft mllw with a 4-ft crest width and 1:1.5 side slopes.
1933	A concrete cap, 840 ft long, was placed on the breakwater crest. The cap was 3 ft high, 1.5 ft wide at the top, and 4 ft wide at the bottom. Breakwater cross sections are shown in Figure 24.
1939	The breakwater was repaired.
1977	The concrete parapet on the breakwater was rehabilitated.
1985	The harbor is illustrated in Figure 24, and an aerial photograph of the harbor is presented in Figure 25. There have been no reports of needed repairs or rehabilitation since 1977.
	Bar Point Basin
1954	The project was authorized, including an 11.9-acre basin and construction of three breakwaters of lengths 700 ft, 1,100 ft, and 450 ft, all of rubble-mound construction with concrete gravity walls on top. During the design stage, the concrete gravity walls were deleted and the rubble-mounds were raised.
1958	The project was completed with the exception of the 450-ft breakwater, which was deferred for restudy. The breakwaters were constructed of a core of dredged material covered by quarry rock and armor rock to a crest elevation of +23 ft mllw, a crest width of 4 ft, and side slopes of 1:1.5. Armor rock weighed 900 to 2,000 lb, and the quarry-run rock weighed less than 2,000 lb with 75 percent of the rock greater than 6 in. The project required 133,000 cu yd of dredged material, 59,900 cu yd of quarry rock, and 21,530 cu yd of armor rock. Breakwater cross sections are shown in Figure 24.
1979	The 450-ft breakwater was deauthorized, and construction was initiated on the floating breakwaters.
1980	The harbor was expanded by 25 acres with the completion of two floating breakwaters, 963 and 120 ft long. The breakwaters were built in the catamaran "Alaskan" style of units that were 40 ft long,

(Continued)

Table 9 (Concluded)

Date(s)	Construction and Rehabilitation History
	21 ft wide, and 6 ft deep. The 963-ft breakwater was aligned nearly tangential to the expected wave energy to minimize overtopping and transmission. The design wave was 3.15 ft and 3.45 sec; the basin was dredged to -15 ft mllw.
1985	The harbor is illustrated in Figure 24, and an aerial photograph of the harbor is presented in Figure 26. There are no reports of needed repairs or rehabilitation.

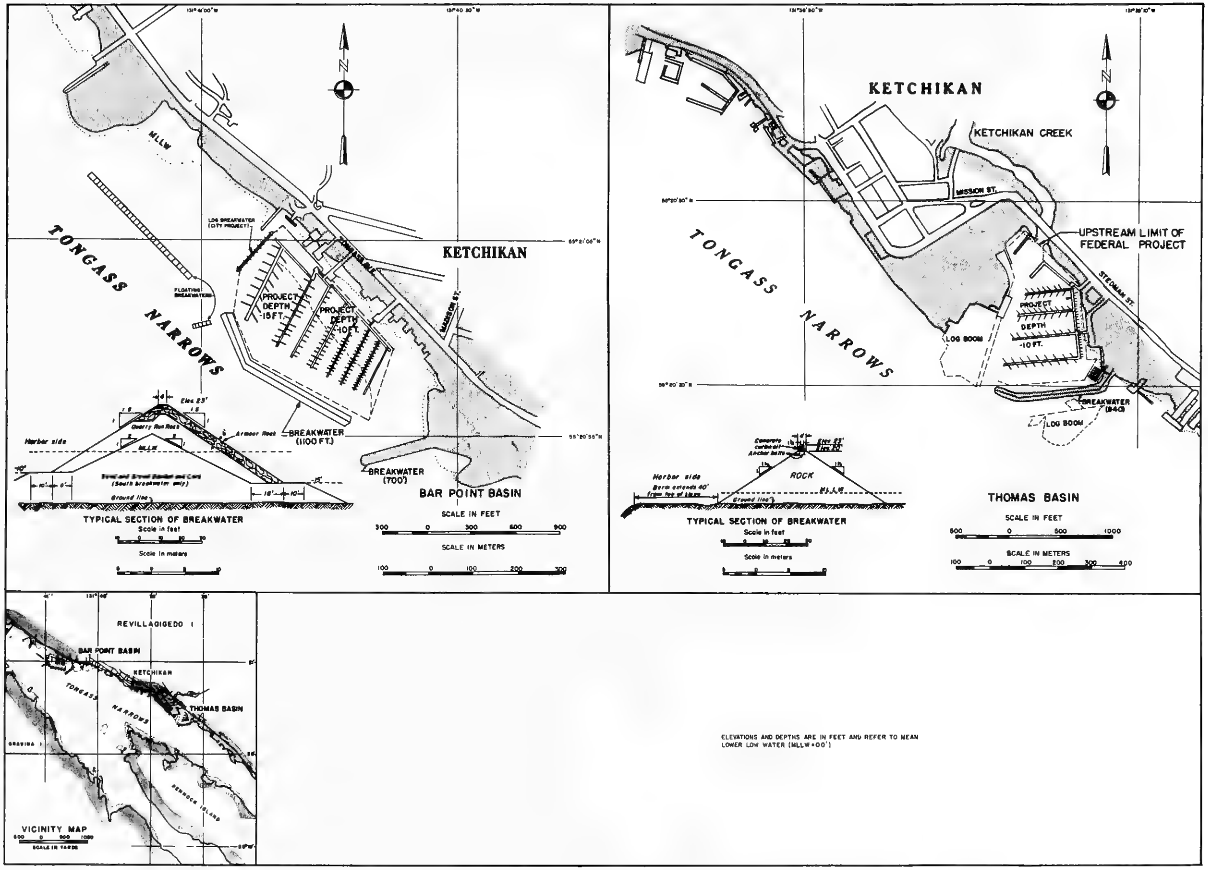

Figure 24. Site layout of Thomas and Bar Point Basins, Ketchikan Harbor, Alaska (revised 1981)

Figure 25. Aerial photograph of Thomas Basin, Ketchikan Harbor, Alaska, 1985

Figure 26. Aerial photograph of Bar Point Basin, Ketchikan Harbor, Alaska, 1985

Table 10

Kodiak Harbor

Kodiak, Alaska

Date(s)	Construction and Rehabilitation History
1935	A channel was authorized between Kodiak Island and Near Island to be 200 ft wide and later dredged to -22 ft mllw.
1954	The project was modified to include a small-boat basin.
1957	Construction of the breakwaters was initiated.
1958	A rock ledge was removed from the basin and channel. Construction of the breakwaters was completed. The southeast breakwater was constructed of a mound of Class "C" stone to an elevation of +18.5 ft mllw, a crest width of 6 ft, side slopes of 1:1.5, and length of 789 ft. The 1,250-ft-long southwest breakwater was constructed to an elevation of +22 ft mllw, a crest width of 6 ft, and side slopes of 1:1.5. The breakwater was constructed of a mound of Class "C" stone covered with a 6-ft layer of armor stone on the crest and a 4-ft layer of armor stone on the seaward side.
1964	The ground subsided 5 ft in an earthquake causing severe damage to the basin and breakwaters. The breakwaters were rebuilt with 70,000 tons of rock. Cross sections of the repaired breakwaters are shown in Figure 27.
1973	The tip of the southeast breakwater was repaired.
1985	The harbor is illustrated in Figure 27, and an aerial photograph of the harbor is presented in Figure 28. There have been no reports of needed repairs or rehabilitation since 1973.

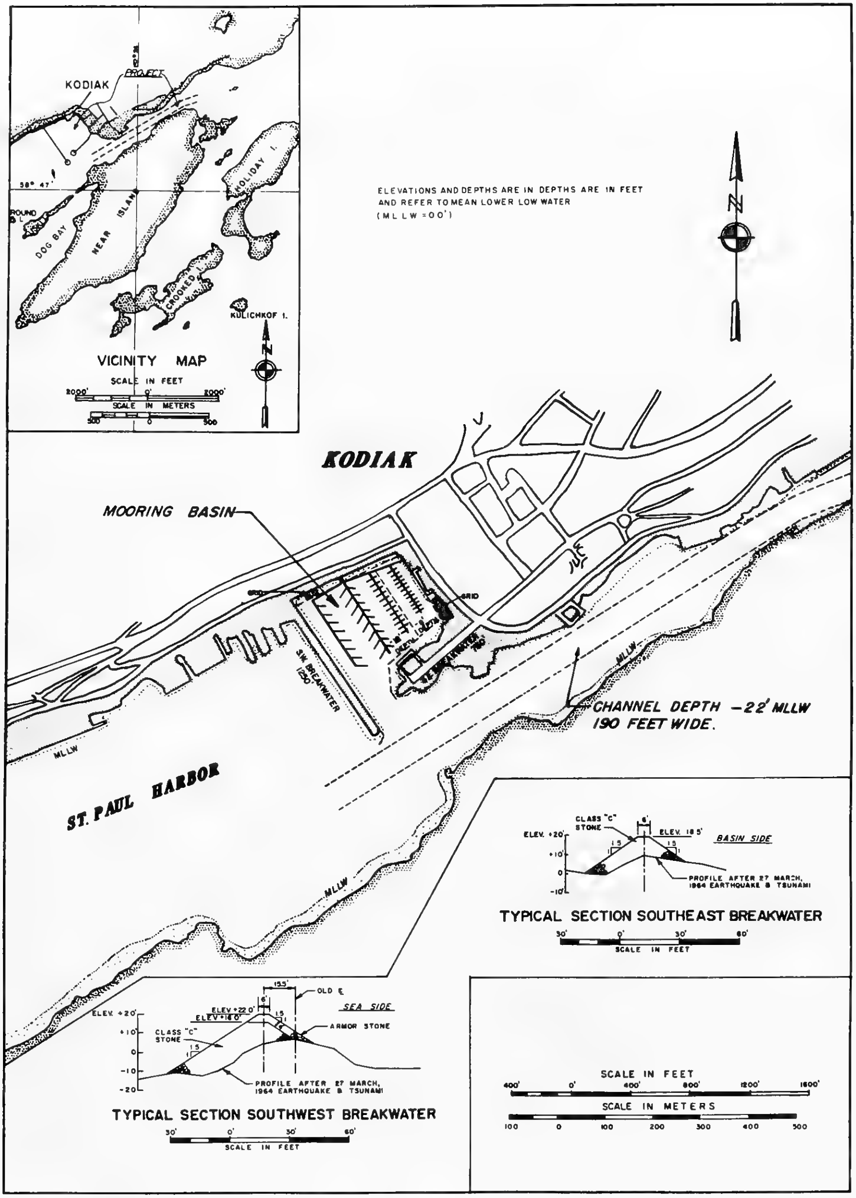

Figure 27. Site layout of Kodiak Harbor, Alaska (revised 1978)

Figure 28. Aerial photograph of Kodiak Harbor, Alaska, 1985

Table 11

Metlakatla Harbor

Annette Island, Alaska

Date(s)	Construction and Rehabilitation History
	Old Harbor
1945	The project was adopted.
1956	The project was completed, including dredging 2.18 acres to -10 ft mllw and constructing a 900-ft rubble-mound breakwater. The breakwater was constructed to elevation +22 ft mllw, crest width of 4 ft, and side slopes of 1:1.5 seaward and 1:1.25 on the basin side. The rock fill core was covered with a 3.5-ft layer of armor rock on the crest and the seaward side. A cross section of the breakwater is shown in Figure 29.
1985	The harbor is illustrated in Figure 29, and an aerial photograph of the harbor is presented in Figure 30. There are no reports of needed repairs or rehabilitation.
	New Harbor
1972	The new harbor project was adopted.
1981	Rubble-mound breakwaters were constructed, including a 1,255-ft west breakwater and a 1,150-ft east breakwater. The breakwaters were constructed to elevation +23.5 ft mllw, crest widths of 6.5 ft except for a 5-ft crest width on the first 660 ft of the east breakwater, and side slopes of 1:1.5. The west breakwater was covered with a 4.5-ft-thick armor layer over a 2-ft-thick layer of secondary rock, on the crest and the seaward sides, and to +12 or +14 ft mllw on the basin side or to the toe on the basin side at the end. The rest of the basin side was covered with a 6.5-ft layer of secondary rock. The east breakwater was covered with armor stone on the crest and to -11 ft mllw on the seaward side and +14 ft mllw on the basin side, and to the toe at the end. The armor layer was 4.5 ft thick, except for a 3.5-ft-thick layer over the first 660 ft, all over a 2-ft-thick secondary rock layer. The secondary rock layer was 6.5 ft thick in areas not covered with armor rock (or 5.5 ft thick over the first 660 ft where not covered with armor rock). All armor rock was Class "A", 900 to 1,500 lb with 50 percent greater than 1,200 lb, except the first 660 ft of the east jetty which was covered with Class "B" armor rock (300 to 900 lb) 50 percent greater than 500 lb. The secondary rock weighed 20 to 300 lb, and the core rock was greater than a #4 sieve and less than 1,000 lb. The design wave was 6.1 ft, nonbreaking. The harbor is illustrated in Figure 31; breakwater cross sections are shown in Figure 32.

(Continued)

Table 11 (Concluded)

Date(s)	Construction and Rehabilitation History
1982	The basin was dredged.
1985	An aerial photograph of the harbor is presented in Figure 33. There have been no reports of repairs or rehabilitation.

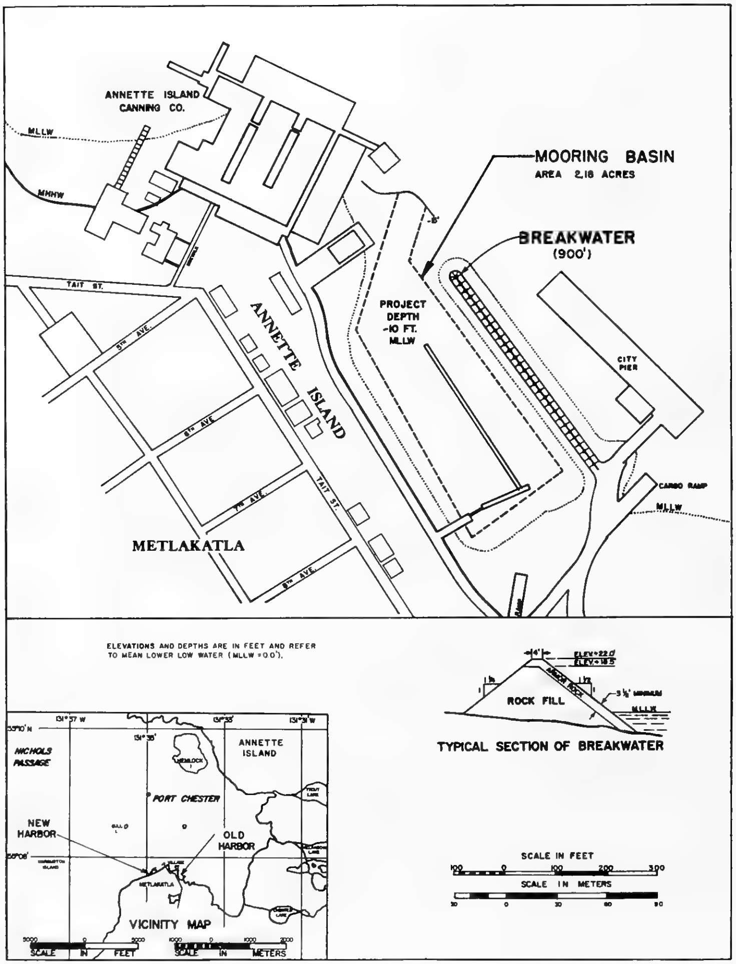

Figure 29. Site layout of Metlakatla Old Harbor, Alaska

Figure 30. Aerial photograph of Metlakatla Old Harbor, Alaska, 1984

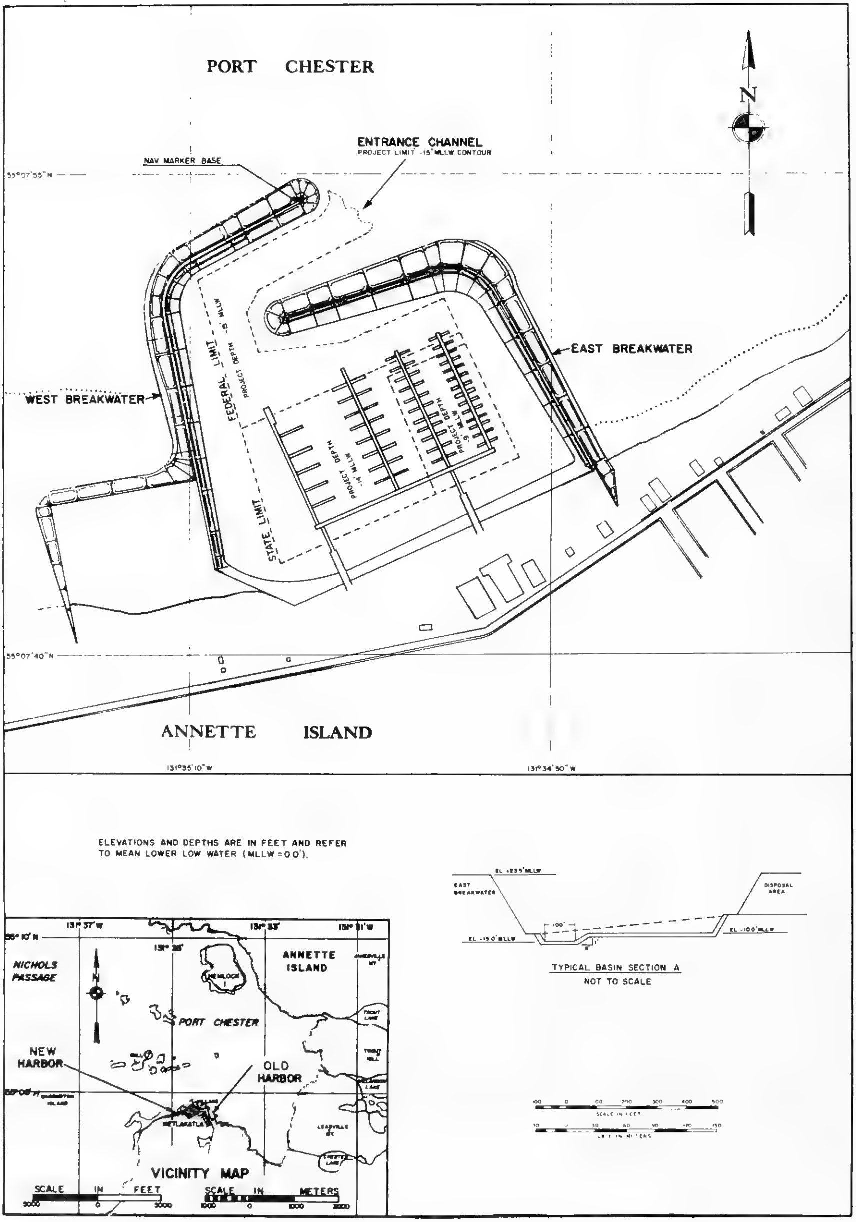

Figure 31. Site layout of Metlakatla New Harbor, Alaska (revised 1984)

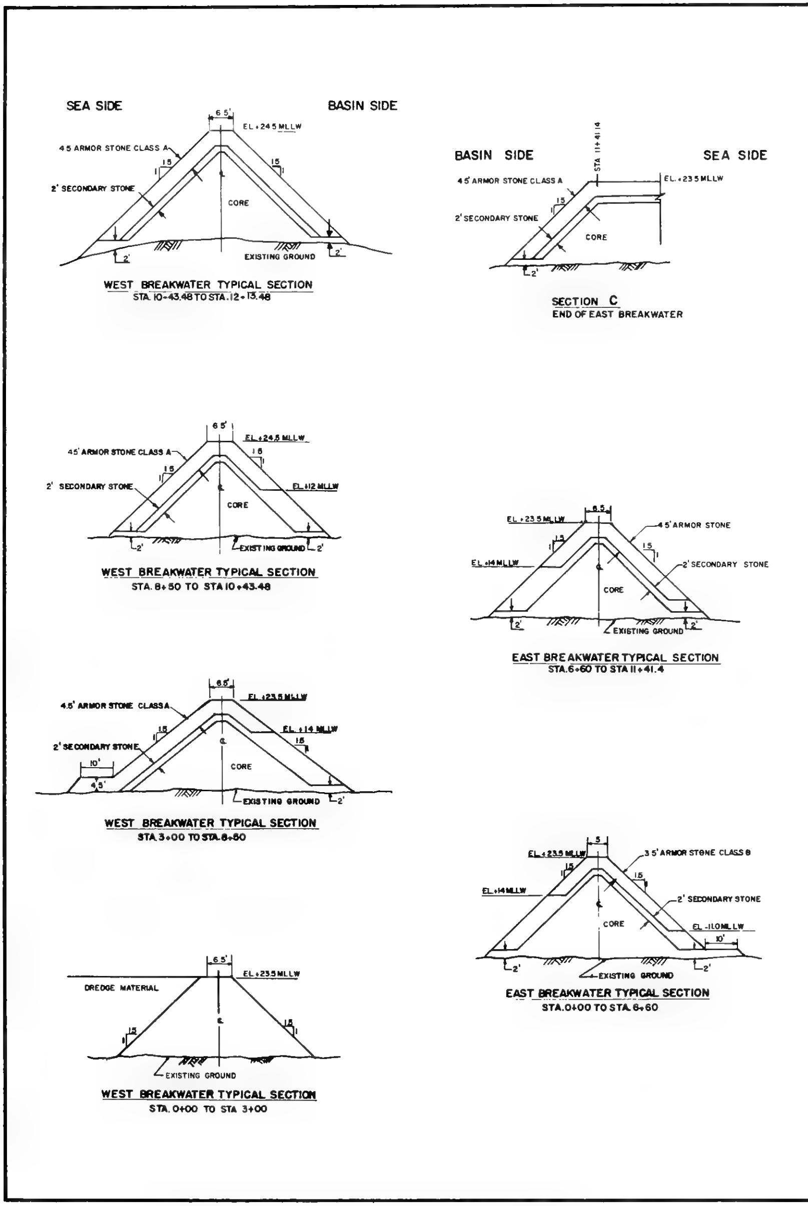

Figure 32. Breakwater cross sections, Metlakatla New Harbor, Alaska

Figure 33. Aerial photograph of Metlakatla New Harbor, Alaska, 1984

Table 12

Ninilchik Harbor

Ninilchik, Alaska

Date(s)	Construction and Rehabilitation History
1958	The project was authorized, including a 320- by 150-ft small-boat basin dredged to +2 ft mllw, a 400- by 50-ft entrance channel dredged to +9 ft mllw, and a 410-ft-long pile jetty located 50 to 100 ft south of the channel entrance.
1961	The harbor was constructed. The pile jetty was deleted, the basin revised to 400 by 120 ft, and rock sills were added upstream and downstream of the basin. The downstream sill was built at a controlling depth of +9 ft mllw.
1962	The spring breakup flood damaged the upstream sill.
1963	The upstream sill was repaired.
1964	The basin subsided 2.5 ft in the earthquake.
1966	The entrance channel was realigned 100 ft north of the design location. A timber groin (200 ft long) was constructed 150 ft south of the entrance channel. The groin was damaged in an October storm, and the entrance channel moved 100 ft farther north.
1967	Major rehabilitation of the harbor was done. The Ninilchik River was diverted to its previous course south of the basin, and two short rubble-mound jetties were constructed at the river mouth. Jetty cross sections are shown in Figure 34.
1980	A study was authorized to determine the feasibility of harbor improvements.
1984	The study determined that improvements to the harbor would not be cost effective.
1985	The harbor is illustrated in Figure 34, and an aerial photograph of the harbor is presented in Figure 35. The harbor has required annual maintenance dredging and repairs since its construction.

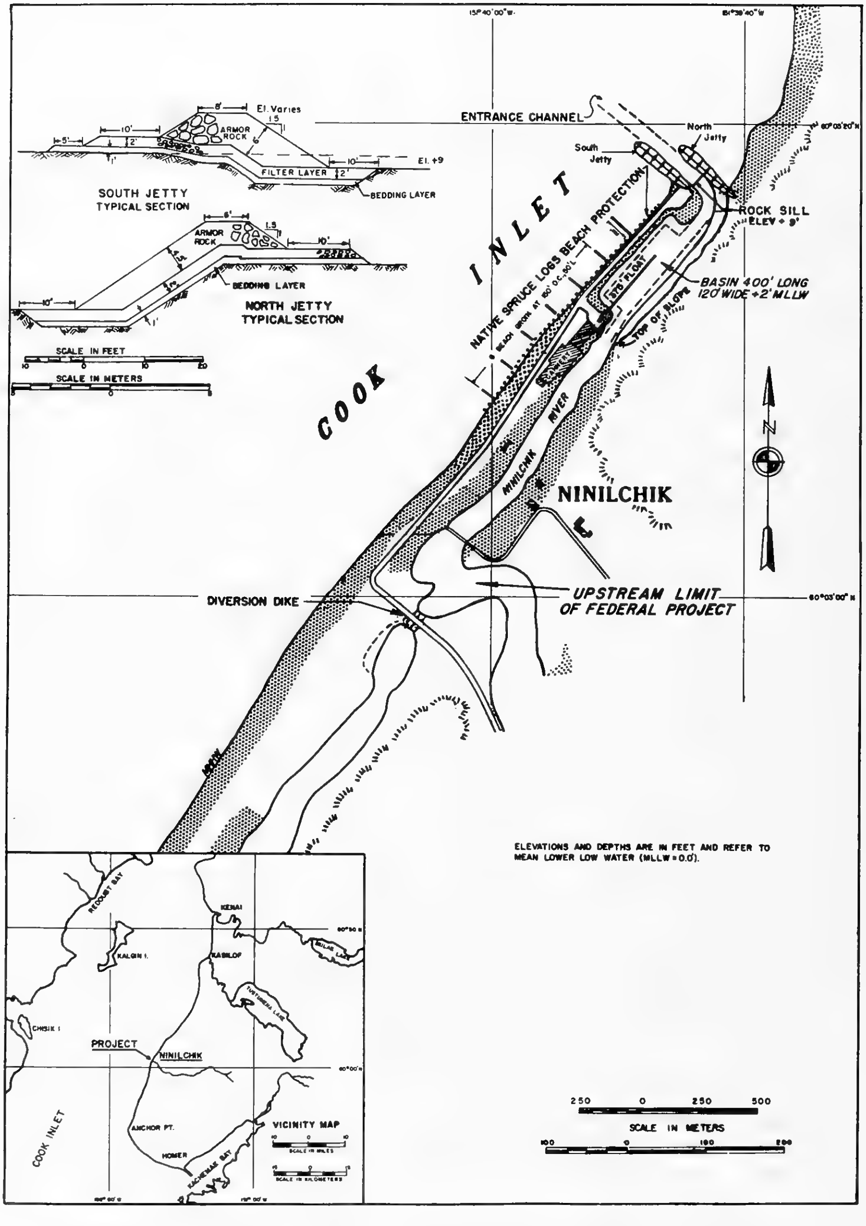

Figure 34. Layout of Ninilchik Harbor, Alaska (revised 1981)

Figure 35. Aerial photograph of Ninilchik Harbor, Alaska, 1980

Table 13

Nome Harbor

Nome, Alaska

Date(s)	Construction and Rehabilitation History
1915	The River and Harbor Act authorized preliminary study of the Nome Harbor project.
1917	The River and Harbor Act authorized construction of the harbor, including a 335-ft east jetty and a 460-ft west jetty and 1,500 ft of riverbank revetment.
1919	Construction was initiated on revetments.
1920	The east jetty was constructed to the 335-ft length, and revetment was completed.
1920-1921	Storms damaged the revetment and jetty, and both were repaired.
1922-1923	The west jetty was constructed to a 460-ft length.
1935	Extension of the east jetty by 240 ft and the west jetty by 216 ft was authorized.
1939-1940	The jetties were reconstructed with steel and concrete to modified lengths of 240 ft for the east jetty and 400 ft for the west jetty. The jetties were reconstructed to an elevation +6.5 ft mllw for the west jetty and +5.5 ft mllw for the east jetty, both with crest widths of 3 ft and 1:1.25 side slopes. The jetties contained a rubble core to elevation 0.0 ft mllw covered with concrete to design height and reinforced with steel "H" columns and steel sheet piles at the toes. A jetty cross section is shown in Figure 36.
1945	A storm damaged 130 ft of the south revetment and destroyed 200 ft of the north revetment. The timber revetment was deteriorating.
1948	Construction of a 3,350-ft seawall along the beach east of the east jetty was authorized.
1949-1950	The seawall was constructed.
1954	The east jetty was repaired with concrete fill.
1955	The extension to jetties authorized in 1935 was made inactive.
1962	Miscellaneous minor jetty repairs were done.

(Continued)

Table 13 (Concluded)

Date(s)	Construction and Rehabilitation History
1973-1974	General maintenance of revetments and jetties was carried out.
1985	The harbor is illustrated in Figure 36, and an aerial photograph of the harbor is presented in Figure 37. No reports have been found of repairs or rehabilitations to the jetties since 1974. The harbor has been dredged by contract since 1979; the seawall is maintained by local interests.

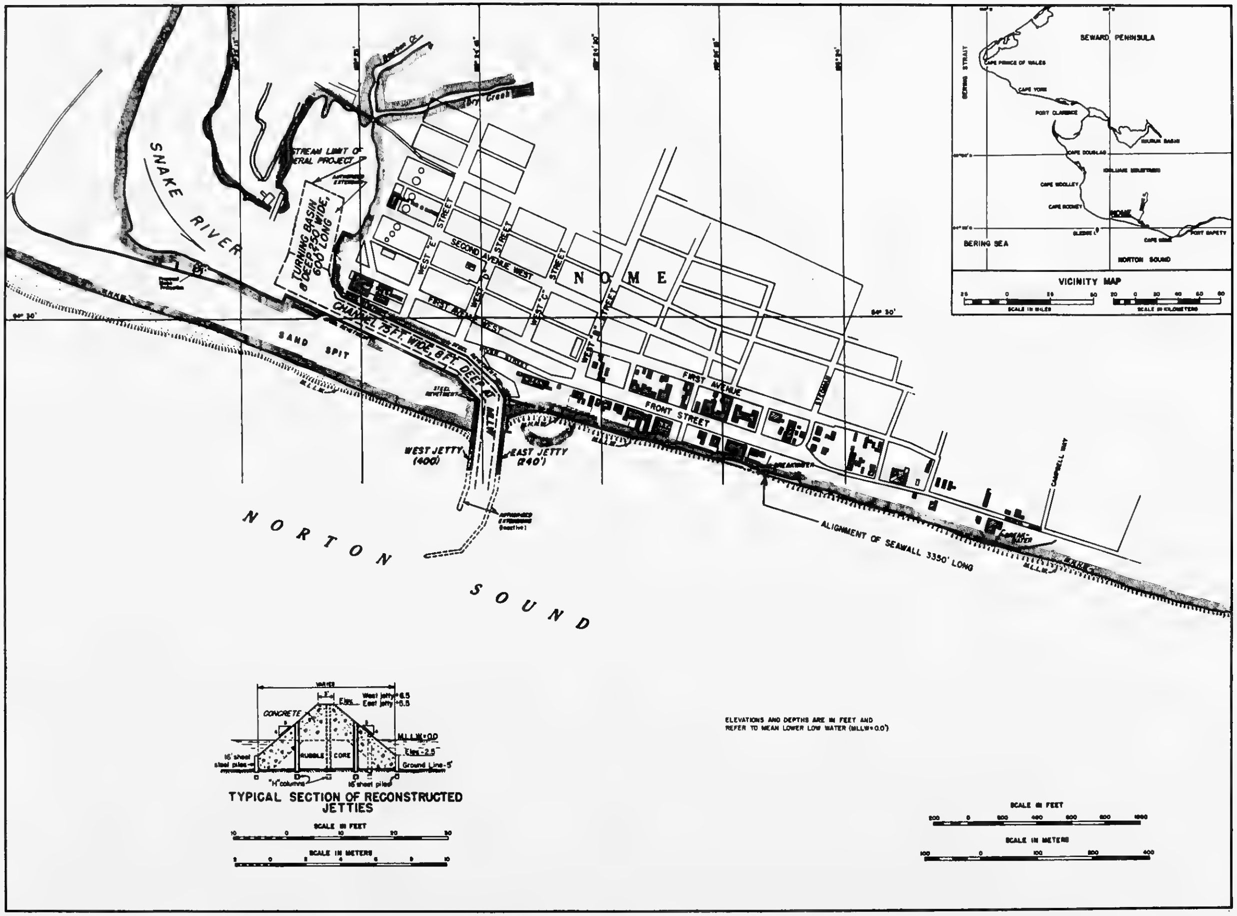

Figure 36. Site layout of Nome Harbor, Alaska (revised 1981)

Figure 37. Aerial photograph of Nome Harbor, Alaska, 1984

Table 14

Pelican Harbor

Pelican, Alaska

Date(s)	Construction and Rehabilitation History
1954	The project was adopted.
1957	The basin was dredged to a project depth of -12 ft mllw with suitable material placed as core for the breakwater.
1957-1958	The breakwater was constructed. Crest elevation was +17 ft mllw, crest width was 4 ft, and side slopes were 1:2. The crest, seaward side, and end were covered with a 2-ft layer of quarry spalls under a 3-ft layer of armor rock. The rest of the basin side of the breakwater was covered with a 4-ft layer of quarry spalls. A breakwater cross section is shown in Figure 38.
1985	The harbor is illustrated in Figure 38, and an aerial photograph of the harbor is presented in Figure 39. There are no reports of needed repairs or rehabilitation.

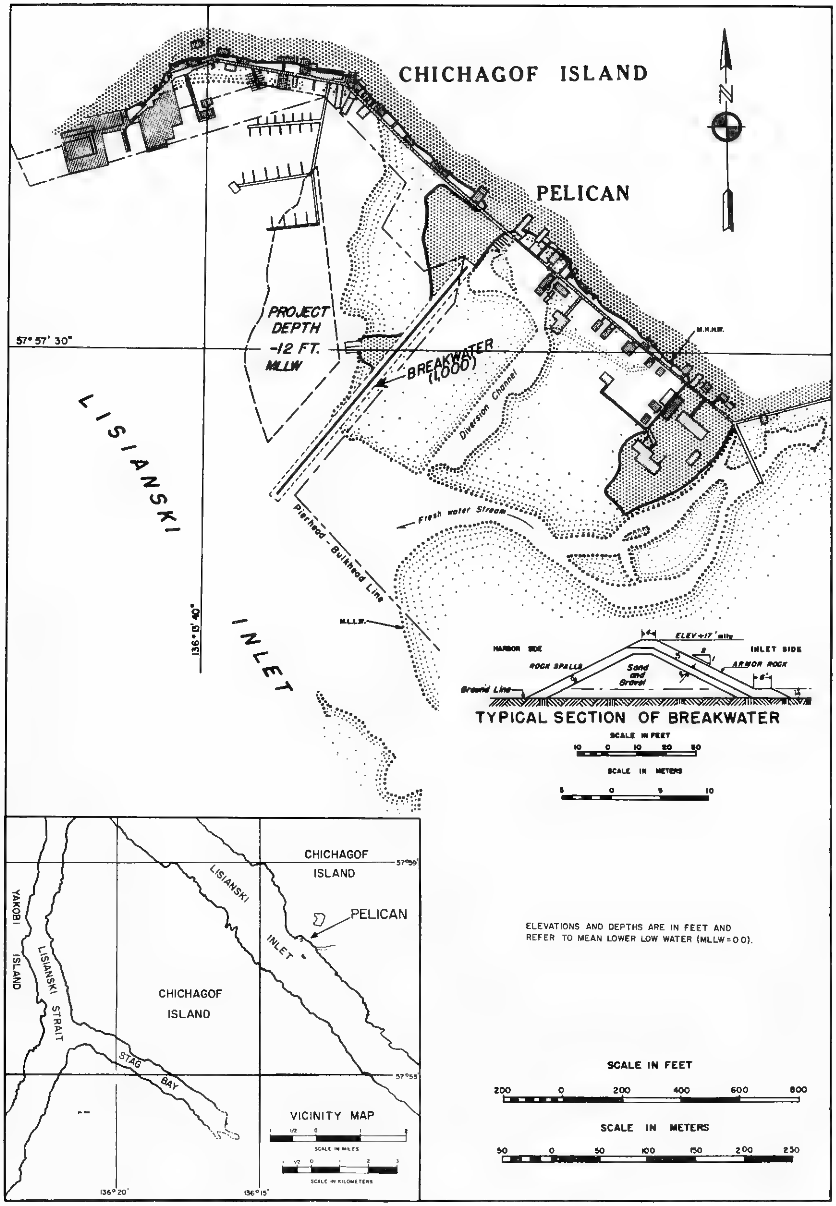

Figure 38. Site layout of Pelican Harbor, Alaska (revised 1981)

Figure 39. Aerial photograph of Pelican Harbor, Alaska, 1985

Table 15

Port Lions Harbor

Port Lions, Alaska

Date(s)	Construction and Rehabilitation History
1965	The town of Port Lions was established. The small-boat basin feasibility study was authorized.
1977	The project was approved for construction by the Office of the Chief of Engineers, including an undredged 12-acre basin protected by a 650-ft north breakwater and a 500-ft south breakwater and an undredged 750- by 150-ft wide entrance channel.
1981	The project was constructed, including an undredged 5-acre basin protected by a 600-ft main breakwater and a 170-ft stub breakwater and an undredged entrance channel. A storm in November destroyed most of the main breakwater.
1983	The main breakwater was rebuilt and lengthened to 725 ft, and an entrance channel was dredged. The breakwater and the extension were rebuilt with a core of 5- to 50-lb stone, a layer of secondary armor rock and a layer of Class "A" armor rock on the crest and seaward sides, and Class "B" armor rock on the basin side. The armor rock in the secondary layer included 95 percent over 50 lb and 30 to 70 percent over 600 lb. The Class "B" armor rock was over 400 lb, with 85 percent over 1,000 lb. The Class "A" armor rock was 98 percent over 3,000 lb and 75 percent over 4,000 lb.
1985	The harbor is illustrated in Figure 40, and an aerial photograph of the harbor is presented in Figure 41. There have been no reports of needed repairs or rehabilitation since 1983.

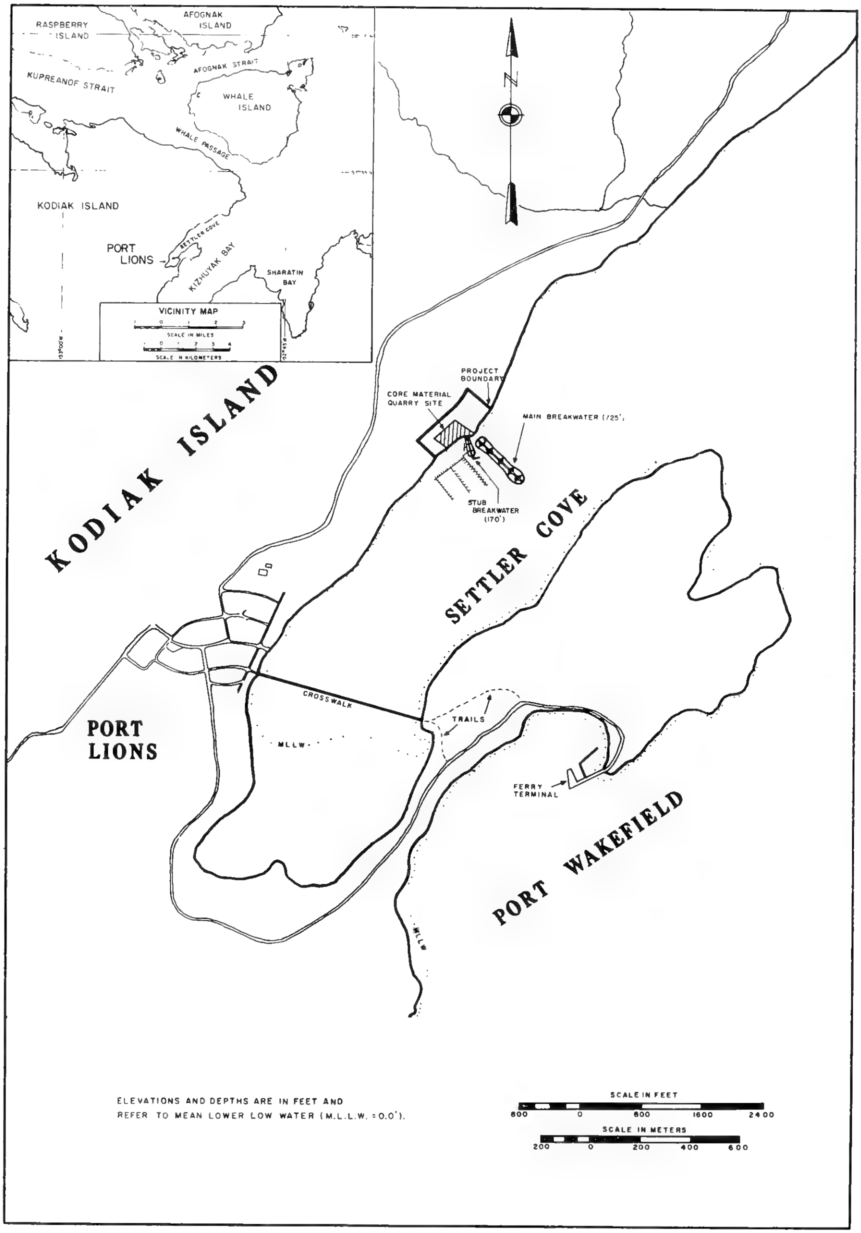

Figure 40. Site layout of Port Lions Harbor, Alaska (revised 1984)

Figure 41. Aerial photograph of Port Lions Harbor, Alaska, 1984

Table 16

Seldovia Harbor

Seldovia, Alaska

Date(s)	Construction and Rehabilitation History
1945	The original project authorized removal of obstructions in the entrance channel.
1958	The basin was authorized, including dredging a 700- by 300-ft basin to -12 ft mllw and constructing a 400- and a 600-ft breakwater.
1961-1962	The project was completed. The 400-ft north breakwater had a crest elevation of +28 ft mllw, crest width of 6 ft, side slopes of 1:1.5, and was constructed of a gravel core covered with a minimum 2-ft-thick layer of quarry spalls. It was covered with a 5-ft-thick layer of armor rock on the crest and bay sides and a 4-ft-thick layer of Class "B" rock on the bay side. The 600-ft detached south breakwater had a crest elevation of +25 ft mllw, crest width of 6 ft, side slopes of 1:1.5, and was constructed of a gravel core covered with a minimum 2-ft-thick layer of quarry spalls and a 4-ft-thick layer of Class "B" rock.
1964	The basin subsided 3.8 ft in an earthquake. The breakwaters were repaired with a 7.5-ft-thick layer of rock on the basin side and a 4-ft-thick layer of armor rock on the crest, raising the crest elevations 0.2 ft over the original design heights, and widening the crests to 8 ft. The repair work required a total of 26,877 tons of stone. Cross sections of the rebuilt breakwaters are shown in Figure 42.
1985	The harbor is illustrated in Figure 42, and an aerial photograph of the harbor is presented in Figure 43. There have been no reports of needed repairs or rehabilitation since 1964.

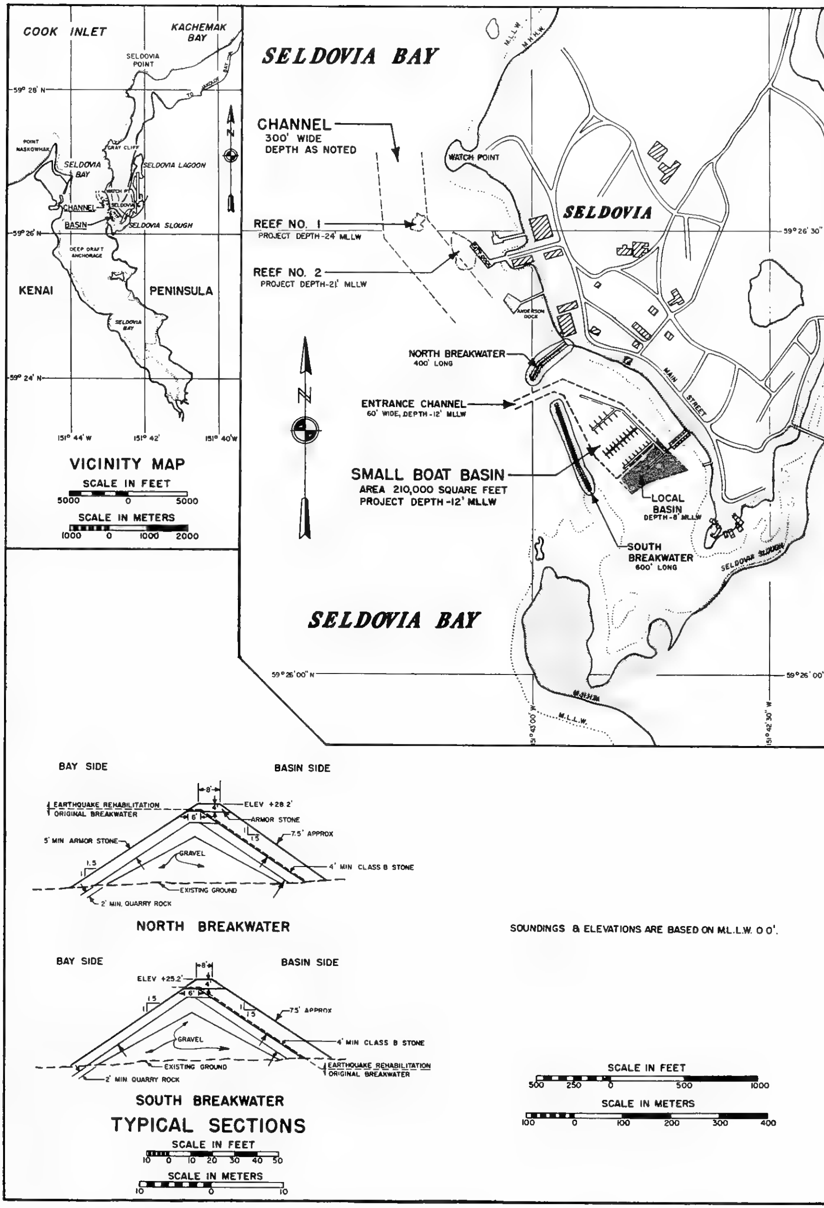

Figure 42. Site layout of Seldovia Harbor, Alaska (revised 1981)

Figure 43. Aerial photograph of Seldovia Harbor, Alaska, 1984

Table 17

Seward Harbor

Seward, Alaksa

Date(s)	Construction and Rehabilitation History
1930	The original harbor was authorized, including a 4.7-acre basin dredged to -12.5 ft mllw and construction of a 580-ft south breakwater.
1931	The south breakwater was constructed.
1932	The boat basin was dredged.
1935	The north breakwater was authorized.
1937	The north breakwater (950 ft long) was constructed.
1953	The north breakwater was raised to project height.
1954	Raising the south breakwater and constructing two pile breakwaters on the east side of the basin were authorized.
1955-1956	The south breakwater was raised, and two pile breakwaters were constructed on the east side of the basin.
1964	The harbor was destroyed by an earthquake. Reconstruction and expansion of the harbor were authorized.
1964-1965	The harbor was relocated and reconstructed, including a 4.75-acre replacement basin dredged to -12.5 ft mllw, a 12.45-acre extension dredged to -15 ft mllw, and construction of a 1,060-ft south breakwater and a 1,750-ft east breakwater. The crest elevations of the breakwaters varied but were approximately +18 ft mllw. The south breakwater and the south portion of the east breakwater had crest widths of 6 ft and 1:1.5 side slopes, and these were constructed of core rock covered with a 4-ft layer of armor rock to the toe on the seaward side and to +9 ft mllw on the basin side. The end 200 ft of the east breakwater had armor rock extending to the toe on both sides. The northern portion of the east breakwater had a crest width of 5 ft and side slopes of 1:1.5, and it was constructed of a rock core covered with a 3.5-ft-thick layer of armor rock extending to the toe on the seaward side and to +9 ft mllw on the basin side. The breakwater cross sections are shown in Figure 44.
1972	Quarry spall beach protection was added at the north end of the basin.
1982	A Detailed Project Report and Final Environmental Impact Statement recommended expansion of the harbor by construction of an additional

(Continued)

Table 17 (Concluded)

Date(s)	Construction and Rehabilitation History
	basin near Nash Road, about 2 miles northeast of Seward. The basin would include 30 acres dredged to depths of -10 to -16 ft and would be protected by a 1,400-ft south breakwater, a 2,500-ft west breakwater, and a 1,700-ft north silt barrier breakwater. The design wave height was 5.0 ft.
1985	The harbor is illustrated in Figure 44, and an aerial photograph of the harbor is presented in Figure 45. There are no reports of needed repairs or rehabilitations, nor are there reports of action taken on recommendations for an additional basin.

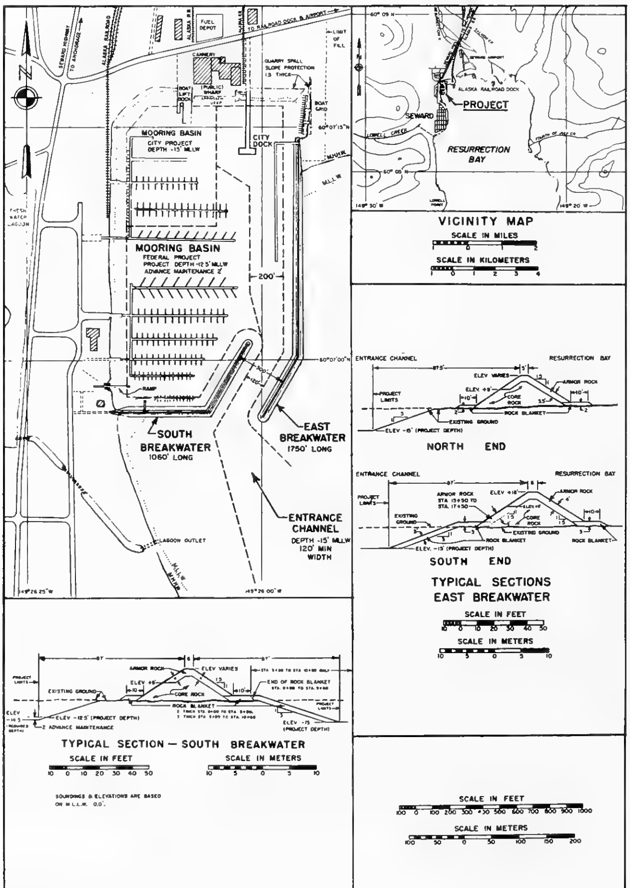

Figure 44. Site layout of Seward Harbor, Alaska (revised 1984)

Figure 45. Aerial photograph of Seward Harbor, Alaska, 1985

Table 18

Sitka Harbor

Sitka, Alaska

Date(s)	Construction and Rehabilitation History
1945	The project was authorized, including a 13-acre basin protected by a 1,430-ft main breakwater and a 200-ft entrance breakwater. The basin was expanded to 15 acres during the design stage.
1964-1965	The project was constructed, including a 15-acre basin dredged to -10 ft mllw and two rubble-mound breakwaters. The breakwaters were constructed to a crest elevation of +19.5 ft mllw, crest width of 8.5-ft, and side slopes of 1:1.5, and these consisted of a rock core with a 4-ft layer of class "B" stone and a 6-ft layer of armor stone. The design wave was 7 ft. Breakwater cross sections are shown in Figure 46.
1967-1971	Wave studies of the harbor were conducted due to damage to small craft within the harbor.
1972-1973	The entrance jetty was extended 135 ft.
1985	The harbor is illustrated in Figure 46, and an aerial photograph is presented in Figure 47. There are no reports of needed repairs or rehabilitation.

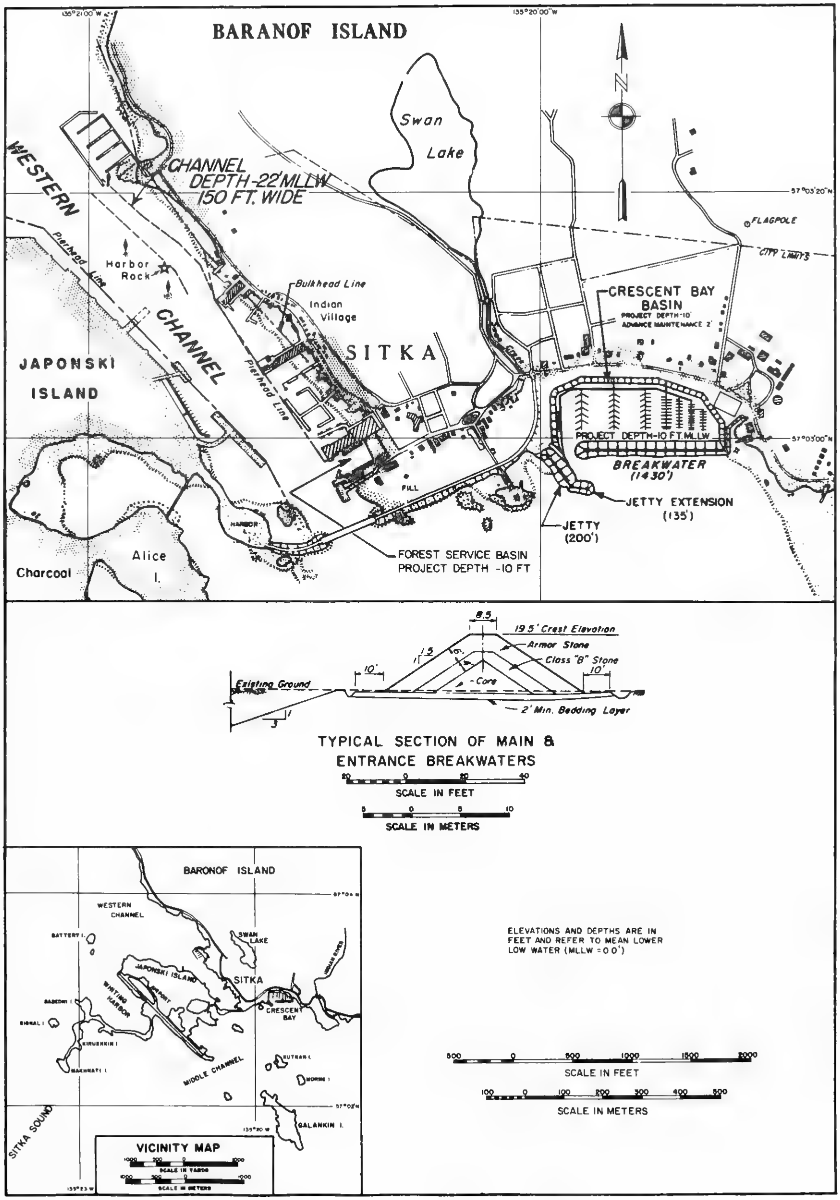

Figure 46. Site layout of Sitka Harbor, Alaska (revised 1981)

Figure 47. Aerial photograph of Sitka Harbor, Alaska, 1985

Table 19

Valdez Harbor

Valdez, Alaska

Date(s)	Construction and Rehabilitation History
1938	The original basin was authorized.
1939	The original basin was dredged, including approximately 3 acres at -12 ft mllw.
1954	The breakwaters were authorized, including a 475-ft rock and gravel breakwater on the southeast side and a 530-ft pile breakwater on the south and west sides.
1957	The breakwaters were completed.
1960	A rock and gravel base was added to the pile breakwater.
1964	The boat basin and townsite were destroyed by an earthquake. A new basin was authorized at the new townsite, including 10 acres dredged to -12 ft mllw, protected by a 625-ft rubble-mound west breakwater and a 685-ft rubble-mound east breakwater.
1965	The new harbor was completed. The breakwaters were constructed to a +19 ft mllw crest elevation, an 8-ft crest width, and 1:1.5 side slopes, with a rock core covered by a layer of secondary rock and a 5-ft layer of armor rock. A breakwater cross section is shown in Figure 48.
1985	The harbor is illustrated in Figure 48, and an aerial photograph of the harbor is presented in Figure 49. The basin was expanded by local interests to 19 acres. There are no reports of needed repairs or rehabilitation at the new harbor.

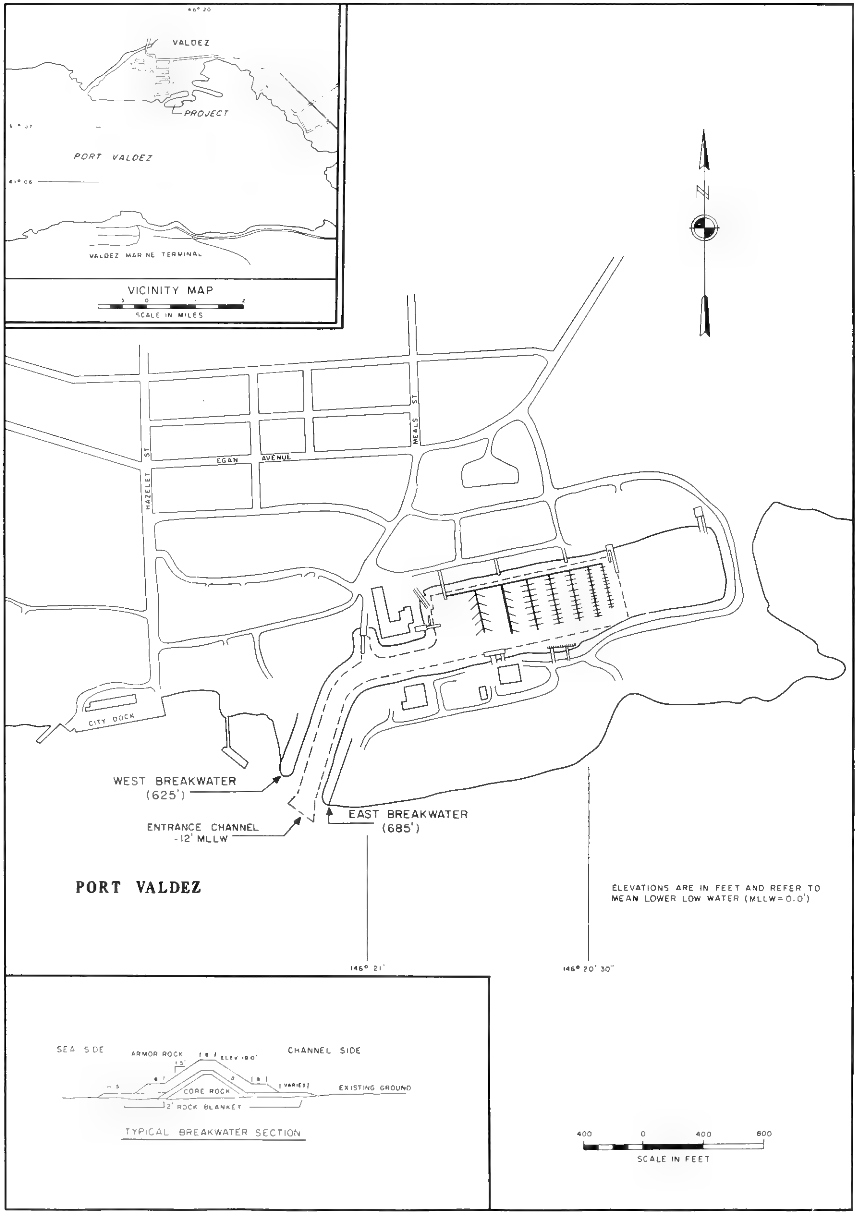

Figure 48. Site layout of Valdez Harbor, Alaska, 1985

Figure 49. Aerial photograph of Valez Harbor, Alaska, 1985

Table 20

Wrangell Harbor

Wrangell, Alaska

Date(s)	Construction and Rehabilitation History
1922	A 300-ft-long breakwater was authorized at Shekesti Point.
1926	The breakwater was constructed. The breakwater was of rubble-mound construction with a crest elevation of +18 ft mllw, crest width of 4 ft, and side slopes of 1:1.5 with a 5-ft-thick layer of armor stone covering the core material. The breakwater was covered with a monolith concrete cap, 4 ft wide at the base, and rising in a curb wall on the sea side of the breakwater to elevation +23 ft mllw. A breakwater cross section is shown in Figure 50.
1935	The outer basin was authorized, including a 600- by 400-ft basin dredged to -10 ft mllw.
1936	The outer basin was dredged.
1945	The inner basin was authorized, including 325- by 550-ft basin dredged to -10 ft mllw, a 530-ft-long by 120-ft-wide connecting channel dredged to -10 ft mllw, and a 320-ft breakwater.
1956-1957	The inner basin and connecting channel were dredged, and the breakwater was deferred.
1985	The harbor is illustrated in Figure 50, and an aerial photograph of the harbor is presented in Figure 51. There are no reports of repairs or rehabilitation.

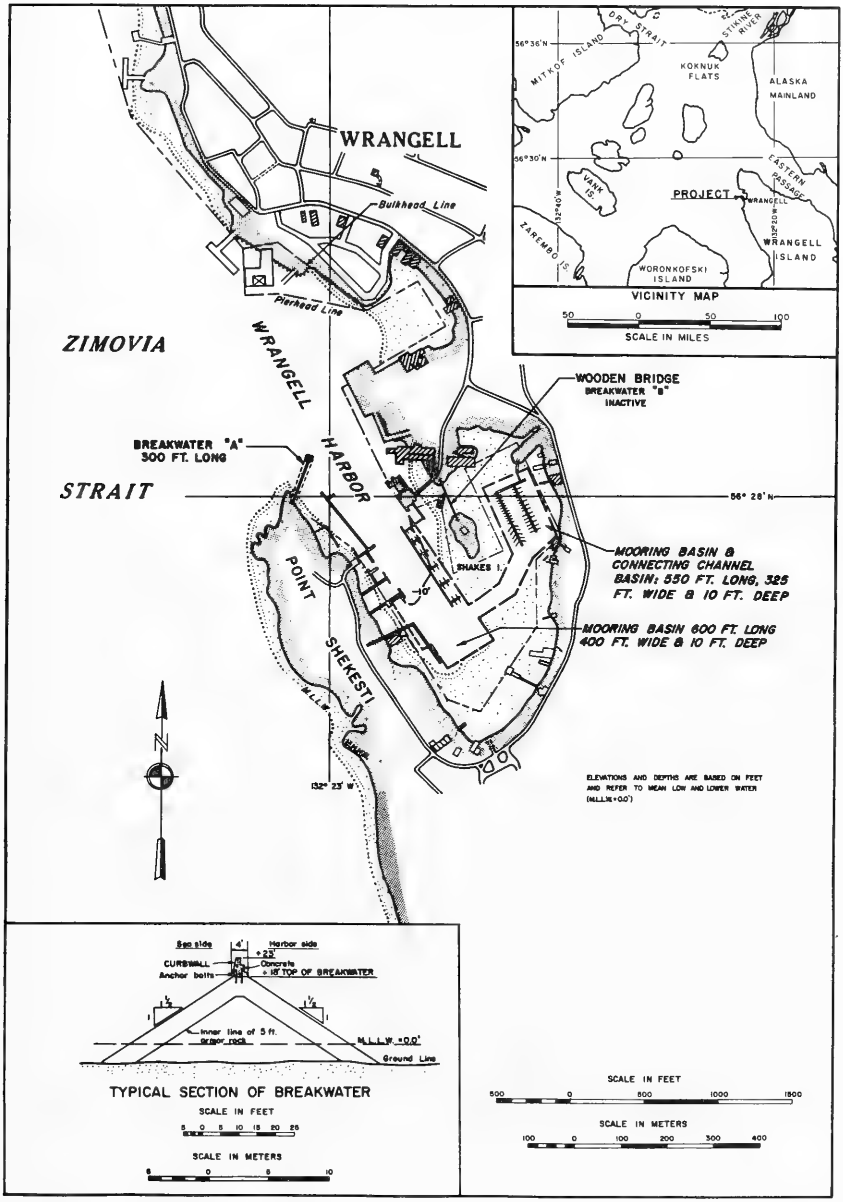

Figure 50. Site layout of Wrangell Harbor, Alaska (revised 1981)

Figure 51. Aerial photograph of Wrangell Harbor, Alaska, 1985

Table 21

Chetco River

Brookings, Oregon

Date(s)	Construction and Rehabilitation History
1957	The jetties were completed. The north jetty was 850 ft long, and the south jetty was 1,550 ft long. The jetties converged to 325 ft apart at the outer ends.
1959	Rock pinnacles and abandoned bridge piers were removed.
1962	The outer 440 ft of the south jetty was repaired and raised to prevent movement of sand and drift into the navigation channel. Select class "A" stone was used on the outer 110 ft. The rest of the repair work placed a 5-ft layer of class "A" stone over a core of class "B" stone. Select class "A" stones weighed more than 12 tons, class "A" stone weighed a minimum of 6 tons and averaged 10 tons, and class "B" stone weighed between 1 and 6 tons and averaged 3 tons.
1968	The north jetty was raised to +16 ft mllw and extended 450 ft. The work required an estimated 61,900 tons of class "A", "B", and "C" stone and 14,800 tons of bedding material. Class "B" stone was placed to raise the inner 800 ft of the jetty to +16 ft mllw. An armor layer of class "A" stone was placed over a core of class "B" and "C" stone on the outer portion of the jetty. The final 50 ft of the jetty was composed entirely of select class "A" stone. Based on a unit weight of 160 pcf, select class "A" stone weighed a minimum of 11.6 tons; class "A" stone weighed a minimum of 8.1 tons and averaged 9.9 tons, placed in a 10-ft-thick armor layer; and class "B" stone weighed a minimum of 5.2 tons, averaged 6.7 tons, and was placed in a layer with a minimum thickness of 9 ft. The rock was placed by a crane on the jetty.
1970	A protective dike was constructed to protect the small-boat basin about 2,500 ft upriver from the jetties. The dike, 1,781 ft long by 18 ft high, was constructed of a gravel embankment covered with a riprap revetment of 12-in. quarry spalls on the river side.
1977	An extension of the north jetty by 750 ft and the south jetty by 1,250 ft was recommended.
1985	The harbor and jetty cross sections are shown in Figure 52. There have been no reports of repairs or rehabilitation since 1970.

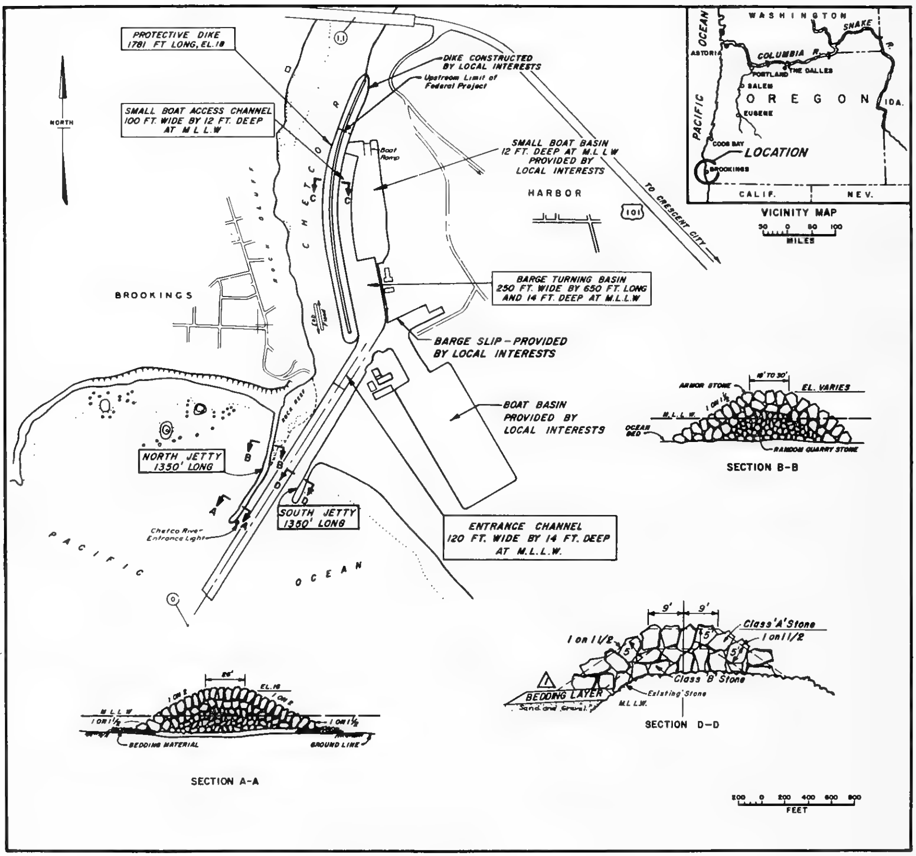

Figure 52. Site layout of Chetco River, Oregon (revised 1979)

Table 22

Columbia River At The Mouth

Astoria, Oregon

Date(s)	Construction and Rehabilitation History
1882	A study was authorized for improvement of navigation at the mouth of the Columbia River. The study, submitted in 1882, recommended construction of a south jetty approximately 4.5 miles long.
1884	Construction of the south jetty was authorized.
1885	Construction of the south jetty was initiated.
1893	The Board of Engineers recommended increasing crest elevation of the jetty to +12 ft mlw at the shore, sloping to +10 ft mlw at a distance of 1.125 miles from shore, then sloping to +4 ft mlw at the outer end. Also recommended was the construction of 4 groins on the north side of the jetty.
1895	The south jetty was completed, including the recommendations made in 1893. Jetty length was 22,440 ft and required 945,923 tons of stone.
1899	The channel depth decreased as the channel shifted to the north. A new study was authorized for stabilization of the channel at -40 ft mllw.
1903	The report authorized in 1899 was submitted for study. The report recommended extending the south jetty 2.5 miles westerly and constructing a north jetty to extend westerly from Cape Disappointment.
1903-1913	The extension to the south jetty was constructed. The extension was 12,514 ft long and required 4,837,311 tons of stone.
1913-1917	The north jetty was constructed to a crest elevation of +28 to +32 ft mllw, a crest width of 25 ft, side slopes of 1:1.5, and length of approximately 2.5 miles.
1931-1937	The inner 3.3 miles of south jetty were rehabilitated with 2,207,613 tons of stone.
1937	The outer 300-ft portion of the south jetty was repaired during 1931-37 with 10,636 tons of stone. The outer 500 ft were impregnated with 12,737 tons of asphaltic mix with 18 percent asphalt and 82 percent beach sand.
1938-1939	The north jetty was rehabilitated except for the outer 1,700 ft. A concrete terminus was placed at the end of the rehabilitated section.

(Continued)

Table 22 (Concluded)

Date(s)	Construction and Rehabilitation History
1939	Jetty "A" was constructed with 233,708 tons of stone weighing a minimum of 6 tons each and averaging 10 tons each.
1940	The south jetty was repaired with 21,392 tons of stone.
1941-1942	The head of the south jetty was repaired with 76,614 tons of stone, plus 27,960 tons (13,980 cu yd) of concrete for the terminus.
1945-1947	The outer 1,800 ft of jetty "A" was reconstructed with 63,125 tons of stone.
1948-1949	The outer 300 ft of jetty "A" was reconstructed with 30,000 tons of stone.
1952	The outer 150 ft of jetty "A" was reconstructed with 6,994 tons of stone.
1953	The outer 400 ft of jetty "A" was reconstructed with 25,005 tons of stone.
1958	Jetty "A" was repaired from sta 41 to sta 79 with 92,400 tons of stone.
1961	The south jetty was reconstructed from shore to "knuckle" with 213,461 tons of stone.
	The 1,800-ft section in the center of jetty "A" and the outer 1,400 ft of jetty "A" were repaired with 92,399 tons of stone.
1964-1965	The south jetty was repaired from "knuckle" to sta 158+00 with 308,101 tons of stone.
1965	The north jetty was rehabilitated with 136,935 tons of stone.
1982	The south jetty was repaired from sta 38+00 to sta 158+00 by filling of cavities in the structure.
1985	The harbor and cross sections of the jetties are illustrated in Figure 53. The north jetty and training jetty "A" have scour problems at the heads. The south jetty is in need of repair.

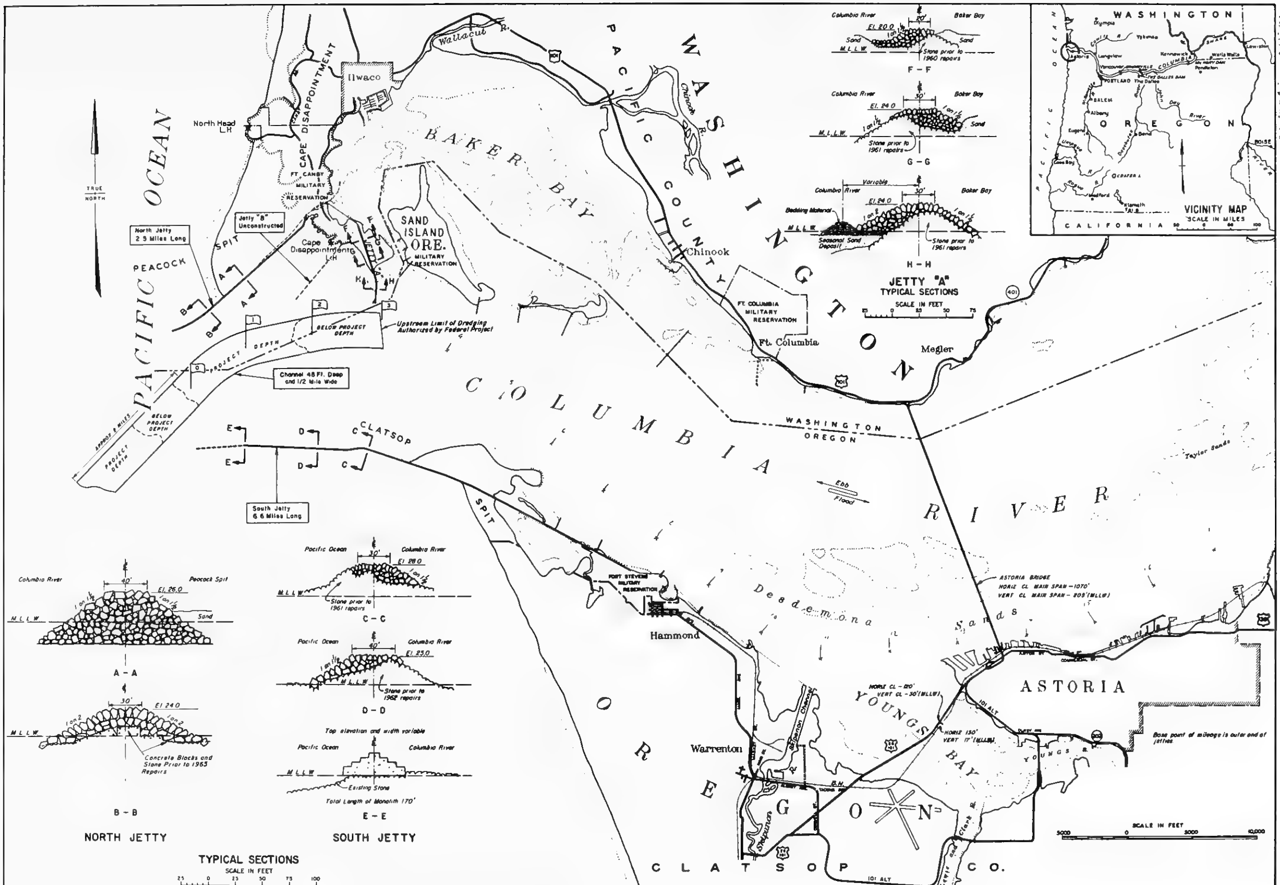

Figure 53. Site layout of Columbia River at Mouth, Oregon and Washington (revised 1979)

Table 23

Coos Bay

Coos Bay, Oregon

Date(s)	Construction and Rehabilitation History
1878	A study was authorized for improvement of navigation at Coos Bay, Oregon. The study recommended construction of a half-tide drift wall or jetty extending seaward from Fossil Point, a second wall (parallel to the first) to confine the channel, and sand fences to prevent wind-blown sand from extending the spit.
1879	The project was adopted then referred to the Board of Engineers for the Pacific Coast who recommended construction of a spur jetty from a point 250 yd below the northern extremity of Fossil Point. The project was authorized in November 1879.
1880	Construction of the spur jetty was initiated.
1884	The spur jetty was constructed at half-tide height to a 1,825-ft length.
1889	The Board of Engineers recommended that two parallel jetties be constructed to confine the channel and that work on the spur jetty be stopped.
1891-1895	The north jetty was constructed to a 9,600-ft length from the high waterline on the seaward side of the north spit. The jetty was of rubble-mound construction on a foundation mattress of pole and brush. Stone used averaged 2 tons with 25 percent weighing 4 to 10 tons and up to 17 tons at the head. The outer 600 ft quickly subsided and was replaced twice by 1900.
1923	No maintenance work has been done on the north jetty since 1900. The outer 1,000 ft were 12 to 20 ft below mean low water. The north jetty fixed the direction of the channel but was unable to maintain satisfactory depths in the channel. The project was therefore modified to restore the north jetty and construct a south jetty in accordance with the project recommended by the Board of Engineers in 1889.
1923-1929	The north jetty was restored to design height, using 690,212 tons of stone.
1924-1928	The south jetty was constructed.
1929-1930	The south jetty was repaired, and a concrete cap was placed on the outer 650 ft of the jetty.

(Continued)

Table 23 (Continued)

Date(s)	Construction and Rehabilitation History
1930	A monolith concrete block was placed at the outer end of the north jetty.
1938-1940	Maintenance work on the north jetty required 236,342 tons of stone. At least 45 percent of the stone above the core was class "A" stone weighing between 6 and 25 tons and averaging 10 tons. The stone was placed by dumping from cars on a tramway.
1941-1942	The south jetty was restored, and monolith concrete cap was placed on the outer 650 ft.
1948	A small-boat mooring basin at Charleston was authorized.
1956-1957	The small-boat mooring basin at Charleston was constructed, including a 2,100-ft breakwater and a silt barrier bulkhead. The breakwater had a crest elevation of +14 ft mllw, a crest width of 18 ft, and required an estimated 67,000 tons of stone, of which at least 35 percent was class "A" stone weighing 3,000 to 8,000 lb and averaging 5,000 lb. No more than 30 percent was class "C" weighing between 25 and 500 lb, and the rest was class "B" weighing 500 to 3,000 lb and averaging 1,000 lb. The stone was placed by dumping from the hauling vehicle.
1957-1958	The outer 2,879 ft of the north jetty was repaired to crest elevation +25 ft mllw and a 30-ft crest width using 246,529 tons of stone. The design specified a minimum of 45 percent class "A" stone weighing at least 6 tons and averaging 10 tons, no more than 20 percent class "C" stone weighing less than 1 ton, and the remaining class "B" stone weighing between 1 ton and 6 tons and averaging 3 tons.
1962-1963	The south jetty was repaired between stations 47+57 and 81+80, requiring 235,000 tons of stone. The armor layer over the outer 1,880 ft consisted of a 10-ft layer of Class "A" stone above mllw, underlain by a 5-ft layer of Class "B" stone in the outer 330 ft. Below mllw, the armor layer consisted of a 5-ft layer of Class "A" stone. Based on a unit weight of 165 to 170 pcf, select class "A" stone weighed a minimum of 16.5 tons, class "A" stone weighed between 9 tons and 16.5 tons and averaged 11 tons, and class "B" stone weighed between 2 tons and 9 tons and averaged 4.5 tons. The rock was placed and keyed by crane.
1969	The north jetty was deteriorating at an average rate of 60 ft annually since the 1957-58 repairs.
1970	The outer 700 ft of the north breakwater was repaired.
	Erosion began on the spit adjacent to and north of the breakwater at the small-boat basin.

(Continued)

Table 23 (Concluded)

Date(s)	Construction and Rehabilitation History
1975	The breakwater at the small-boat basin was repaired.
1977	The breakwater at the small-boat basin was repaired twice.
1982	The breakwater at the small-boat basin was extended 700 ft and rehabilitated. The design called for an 800-ft extension, but severe scour ahead of the work caused cost overruns which necessitated deleting the last 100 ft of the extension.
1985	The harbor and cross sections of the jetties and breakwater are illustrated in Figure 54. The south jetty is in good condition, but the outer 200 ft of the north jetty is in a deteriorated condition and has severe scour. The breakwater is in good condition.

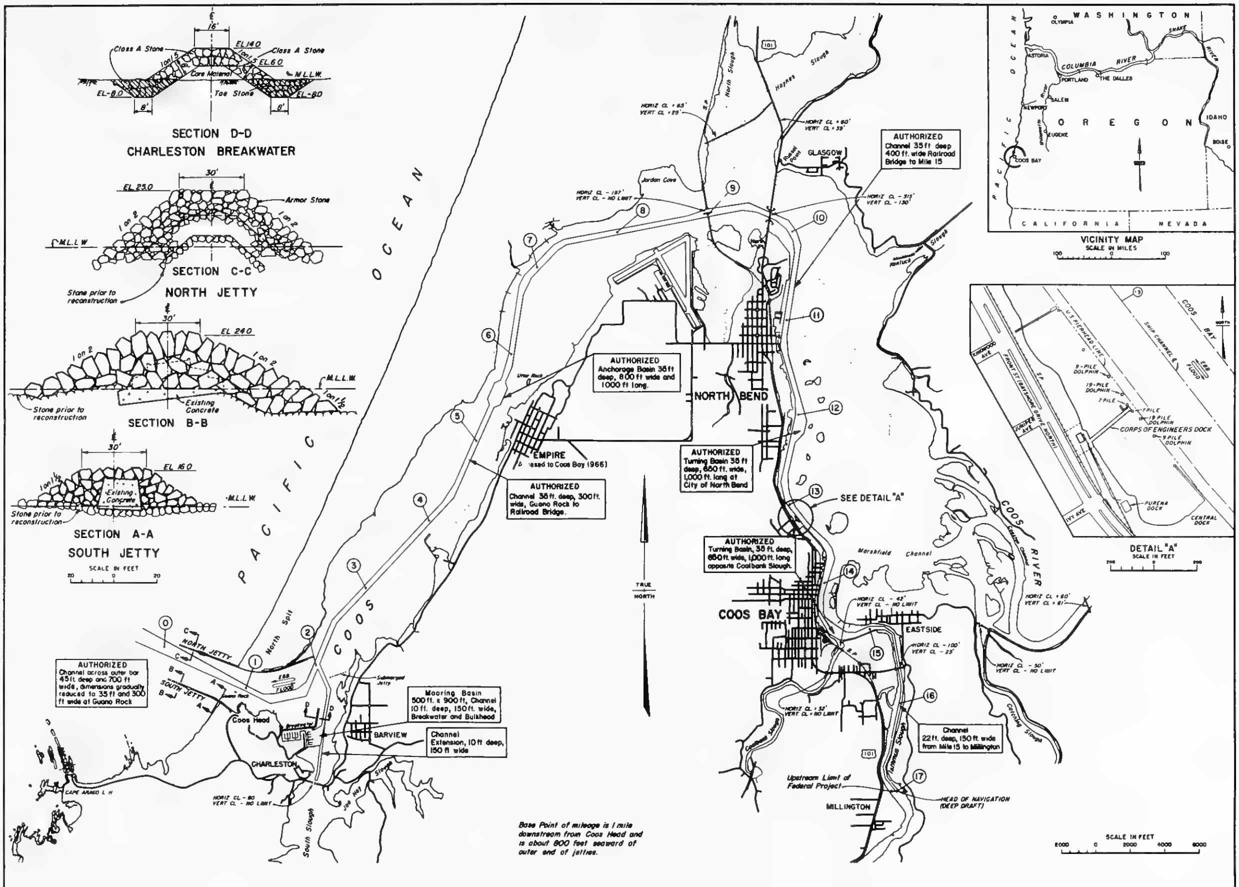

Figure 54. Site layout of Coos Bay, Oregon (revised 1979)

Table 24

Coquille River

Bandon, Oregon

Date(s)	Construction and Rehabilitation History
1880	The jetties were authorized.
1907	Two high-tide, rubble-mound jetties were completed. The north jetty was 3,450 ft long; the south jetty was 2,700 ft long.
1942	The outer 1,600 ft of the north jetty was rerocked and capped with concrete requiring an estimated 55,000 tons of stone and 10,000 cu yd of concrete. The stone was 60 percent class "A", weighing between 1 ton and 10 tons with an average of 6 tons, and 40 percent class "B", weighing between 50 lb and 1 ton, with half the class "B" stone weighing over 500 lb. The crest of the concrete cap was at elevation +15 ft mllw, the crest of the jetty was 34 ft wide, and side slopes were 1:1.5.
1951	A 750-ft shoreward extension was added to the east end of the north jetty.
1954	The outer 450 ft of the south jetty was repaired with 30-35,000 tons of stone. Capstones were of an 8-ton average with a 6-ton minimum, and the core was "B" stone over 2 tons, with select "A" stones up to 10 tons on the west end slope at the outer end of the jetty. The crest was 20 ft wide at elevation +20 ft mllw, and side slopes were 1:2. The design was for an average storm wave height of 10 to 12 ft.
1956	The north jetty was repaired, including placing concrete under the jetty cap in voids caused by erosion of the cap foundation stones and placing jetty stone along the north and south sides of the jetty cap. Stones were 50 percent class "A", weighing at least 4 tons and averaging 6 tons, and 50 percent class "B", weighing at least 1 ton and averaging 2 tons.
1982	The small-boat basin was constructed at Bandon, Oregon, including construction of a rubble-mound breakwater about 350 ft long with a crest elevation of +14 ft mllw and a crest width of 6 ft.
1985	The harbor and cross sections of the jetties are illustrated in Figure 55. The head of the north jetty is in need of repair, but it is still functional. The south jetty is in good condition.

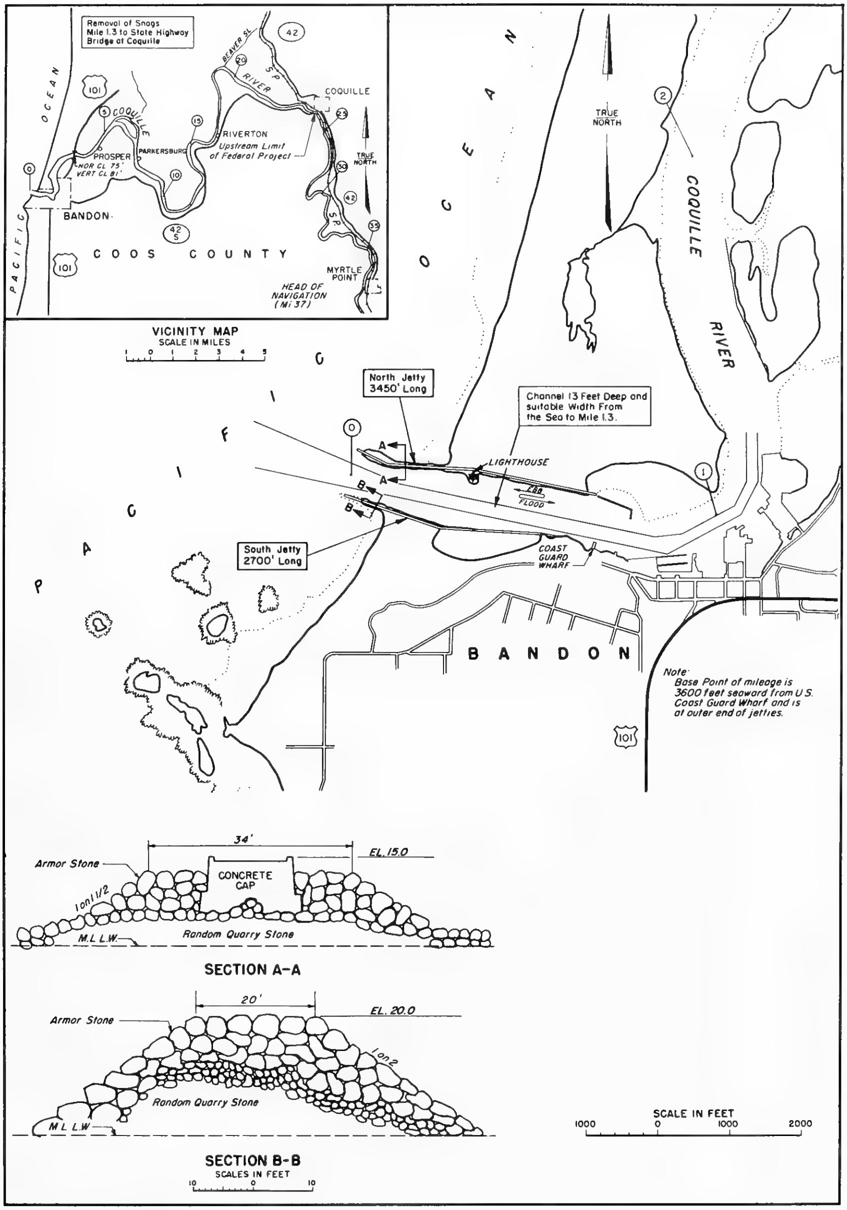

Figure 55. Site layout of Coquille River, Oregon (revised 1981)

Table 25

Depoe Bay

Depoe Bay, Oregon

Date(s)	Construction and Rehabilitation History
1937	The project was authorized.
1939	The project was completed, including basin and channel.
1945	Project expansion was authorized.
1952	Expansion was completed, including expanding the basin, constructing a retaining wall on the easterly side of the basin, deepening the channel, and constructing a 160-ft breakwater on the north entrance to the bay. The breakwater was a concrete gravity type with crest elevation +10 to +14 ft mllw.
1960	Project expansion was authorized.
1966	Expansion was completed, including widening the entrance channel to 50 ft and constructing a second breakwater on the north entrance to the basin. The breakwater was a gravity type, constructed of concrete. The crest elevation was +16 ft mllw, with an additional 4-ft-high by 2-ft-thick parapet at the westerly end.
1985	The harbor and cross sections of the jetties are illustrated in Figure 56. No needed repairs or rehabilitation are reported.

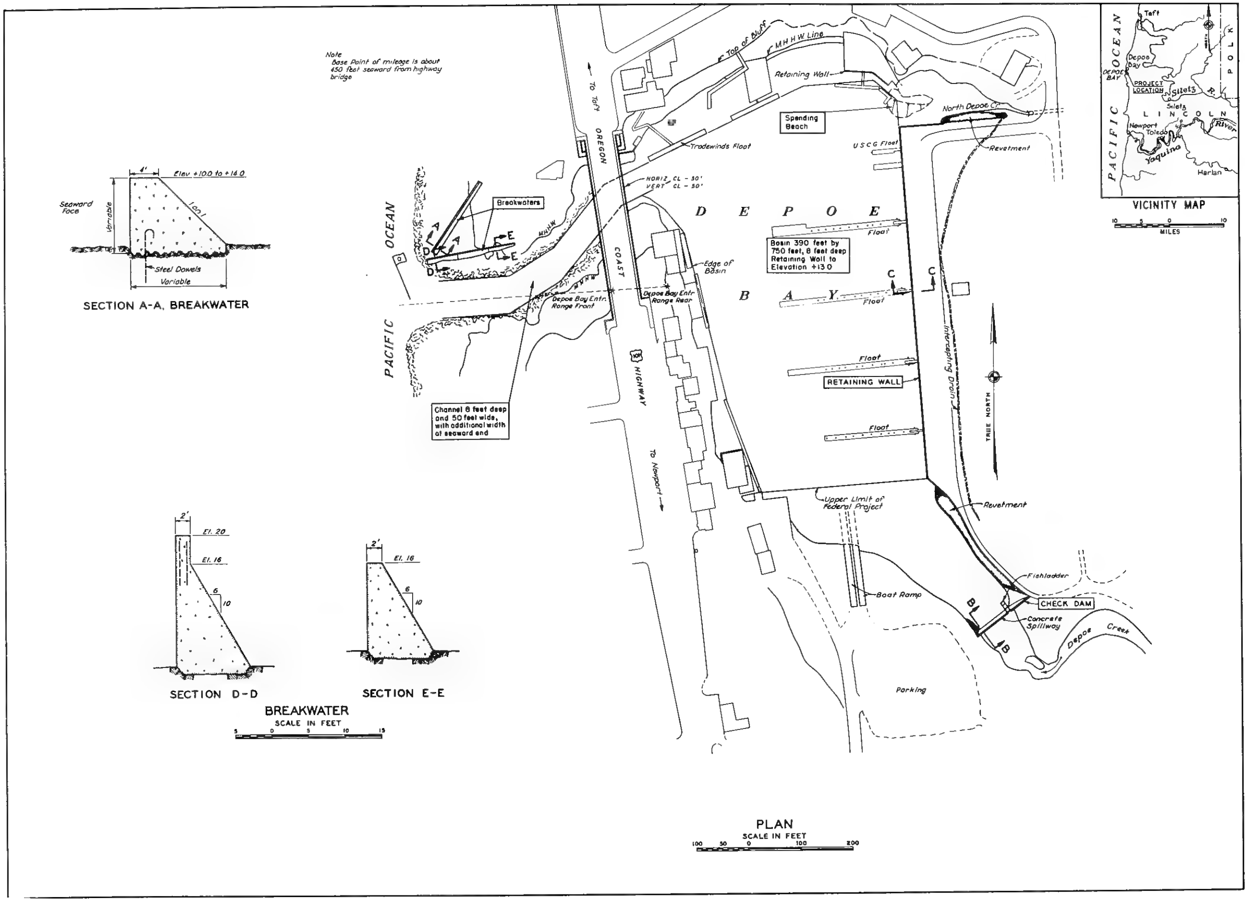

Figure 56. Site layout of Depoe Bay, Oregon (revised 1976)

Table 26

Nehalem River

Oregon

Date(s)	Construction and Rehabilitation History
1890	The initial project was authorized.
1898	The initial project was terminated before construction had begun.
1910	Local interests began construction of the south jetty.
1912	The existing project was authorized, including two high-tide rubble-mound breakwaters 700 ft apart at the outer ends.
1915	Construction of the south jetty was completed. The jetty was 4,500 ft long, including the work begun by the local interests in 1910. Crest elevation was +10 ft mllw with a 10-ft crest width and 1:1 side slopes for the first 3,000 ft, and crest elevation was +12 ft mllw with a 15-ft crest width and 1:1.5 side slopes for the outer 1,500 ft.
1918	Construction of the north jetty was completed. The jetty was 3,300 ft long. The crest elevation was +10 ft mllw with a crest width of 15 ft for the first 1,600 ft, and crest elevation was +12 ft mllw with crest width of 20 ft for the seaward half of the jetty, all with side slopes of 1:1.5.
1919	Jetty subsidence and storm-related damage had lowered the outer 200 ft of both jetties below low water.
1934	The project was classified inactive. The seaward 200 ft of the north jetty was below mllw, and the rest of the structure was between +3 and +5 ft mllw, with the highest elevation at +9 ft mllw. The outer 220 ft of the south jetty was below mllw, with the remaining length predominantly below mllw.
1979	The outer 200 ft of the north jetty was below mllw, the majority of the structure was below +6 ft mllw, and the maximum elevation was +7 ft mllw. Approximately 700 ft of the north jetty shoreward of the high waterline on the spit was covered with sand. The outer 400 ft of the south jetty was below mllw, the next 1,400 ft was at about +3 ft mllw, and the remainder of the structure was at about +5 ft mllw, with a maximum elevation of +7 ft mllw.
1981	Major rehabilitation of 3,500 ft of the north jetty and 4,400 ft of the south jetty was undertaken. The jetties were rebuilt to a crest elevation of +16 ft mllw, crest width of 26 ft, and side slopes of 1:1.5. Estimated stone required for the north jetty included 63,600 tons of class "A", 40,100 tons of class "B", 12,800 tons of core stone, and 9,500 tons of bedding stone. The south jetty

(Continued)

Date(s)	Construction and Rehabilitation History
1981 (Cont)	required an estimated 66,900 tons of class "A" stone, 104,000 tons of class "B", 40,300 tons of core stone, and 10,500 tons of bedding stone. Class "A" stone had a minimum weight of 7.0 tons and an average weight of 9.3 tons; class "B" stone had a minimum weight of 4.2 tons and an average weight of 5.6 tons. All weights were based on a unit weight of 170 pcf. Stone placement during construction was not as precise as desired due to inexperience of the contractor. However, the stones were sufficiently overweight that the jetties should be stable.
1985	The harbor and cross sections of the jetties are illustrated in Figure 57. The jetties are in good condition at this time.

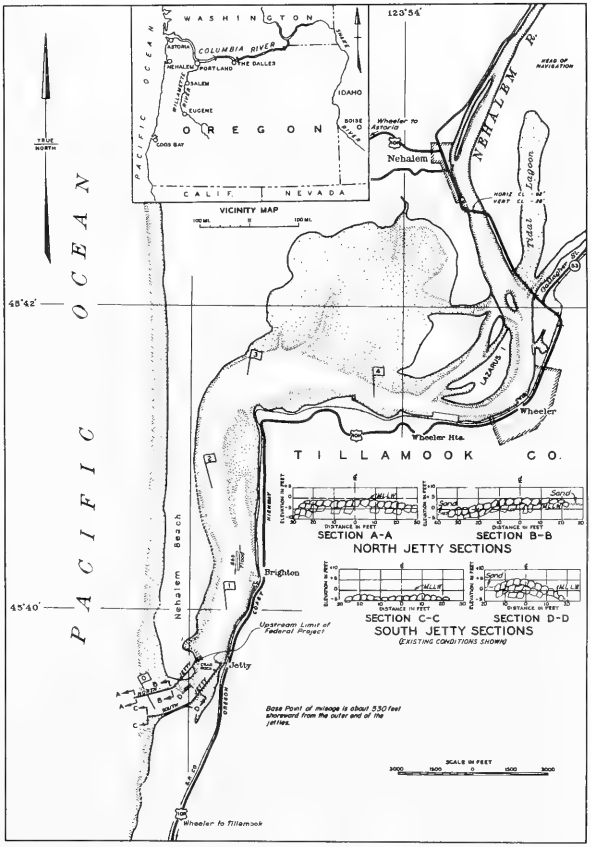

Figure 57. Site layout of Nehalem Bay, Oregon (revised 1979)

Table 27

Port Orford

Port Orford, Oregon

Date(s)	Construction and Rehabilitation History
1935	Local interests built a combined breakwater-pier of piling, concrete, and stone. The breakwater was rebuilt three times between 1935 and 1965 due to damage from winter storms.
1965	An extension to the breakwater was authorized.
1968	The breakwater extension was constructed. The extension was 550 ft long with crest elevation of +20 ft mllw and crest width of 30 ft. Side slopes were 1:1.5 on the harbor side and on the ocean side below mlw and 1:2 on the ocean side above mlw. The project required an estimated 79,000 tons of stone as well as 11,000-16,000 tons for the bedding layer. Fifty-eight percent of the stone was class "A" (9 to 15 tons and averaging 12 tons). Twenty-two percent of the stone was class "C" (weighing a minimum of 1,000 lb and averaging 1 ton). The remainder of the stone was class "B" (weighing a minimum of 2 tons and averaging 6 tons). The design wave was the 10 percent wave, estimated at 22 ft.
1985	The harbor and cross section of the breakwater are illustrated in Figure 58. No repairs or rehabilitation are reported.

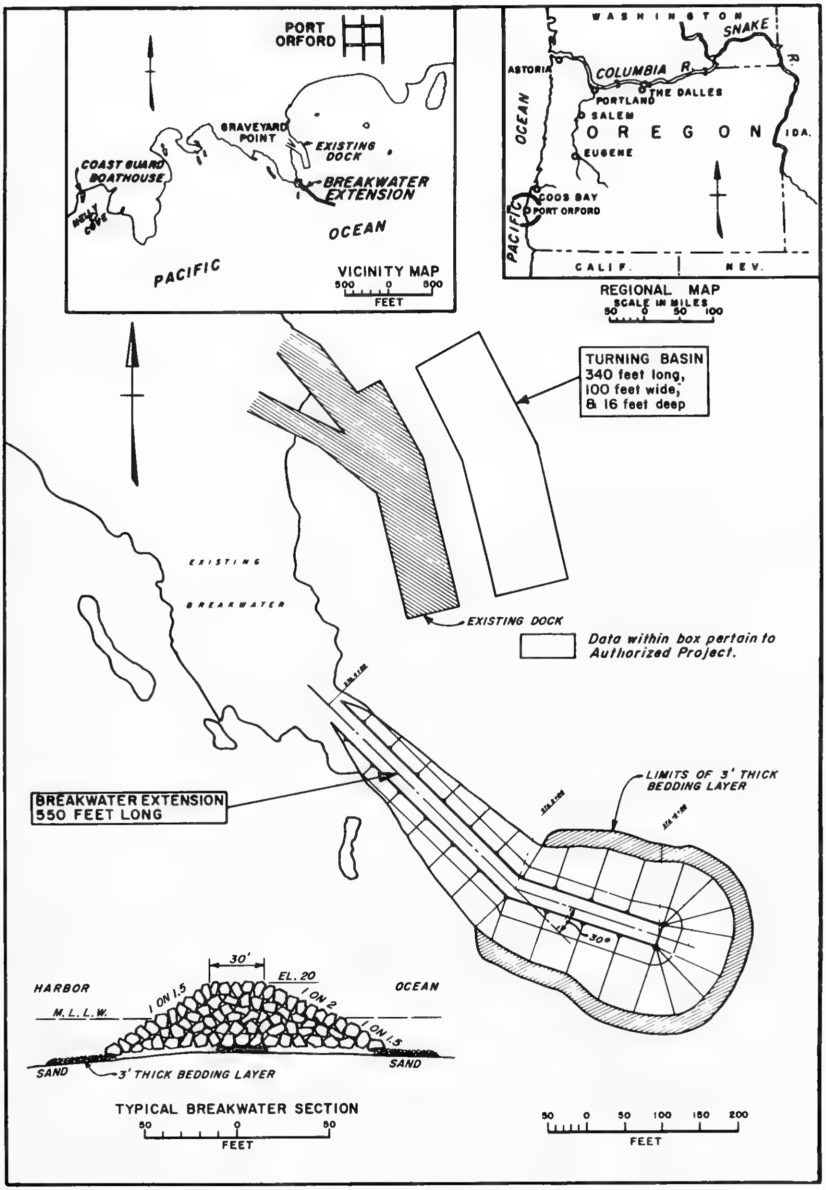

Figure 58. Site layout of Port Orford, Oregon (revised 1971)

Table 28

Rogue River

Gold Beach, Oregon

Date(s)	Construction and Rehabilitation History
1954	The project was authorized.
1959	The south jetty was completed. The 3,400-ft-long jetty was of rubble-mound construction, with 1:1.5 side slopes, and it consisted of 216,069 tons of stone. The seaward 1,700 ft had a crest elevation of +19 ft mllw and a crest width of 26 ft; the rest of the jetty had a +15-ft mllw crest elevation and a 20-ft crest width. Armor stone was greater than 6 tons and averaged 10 tons.
1960	The north jetty was completed. The 3,300-ft-long jetty was of rubble-mound construction, with 1:1.5 side slopes, and it consisted of 462,767 tons of stone. The crest elevation was +19 ft mllw with a crest width of 26 ft.
1964	The highest flood on record damaged the north jetty.
1966	The north jetty was rehabilitated, requiring an estimated 67,500 tons of class "B" stone and 32,000 tons of quarry spalls and bedding material. The class "B" stone was placed as an 8-ft-thick armor layer on the underwater slope of the jetty in the damaged area, and it weighed between 1 and 6 tons.
1985	The harbor and cross section of the jetties are illustrated in Figure 59. There is some localized damage on the jetties.

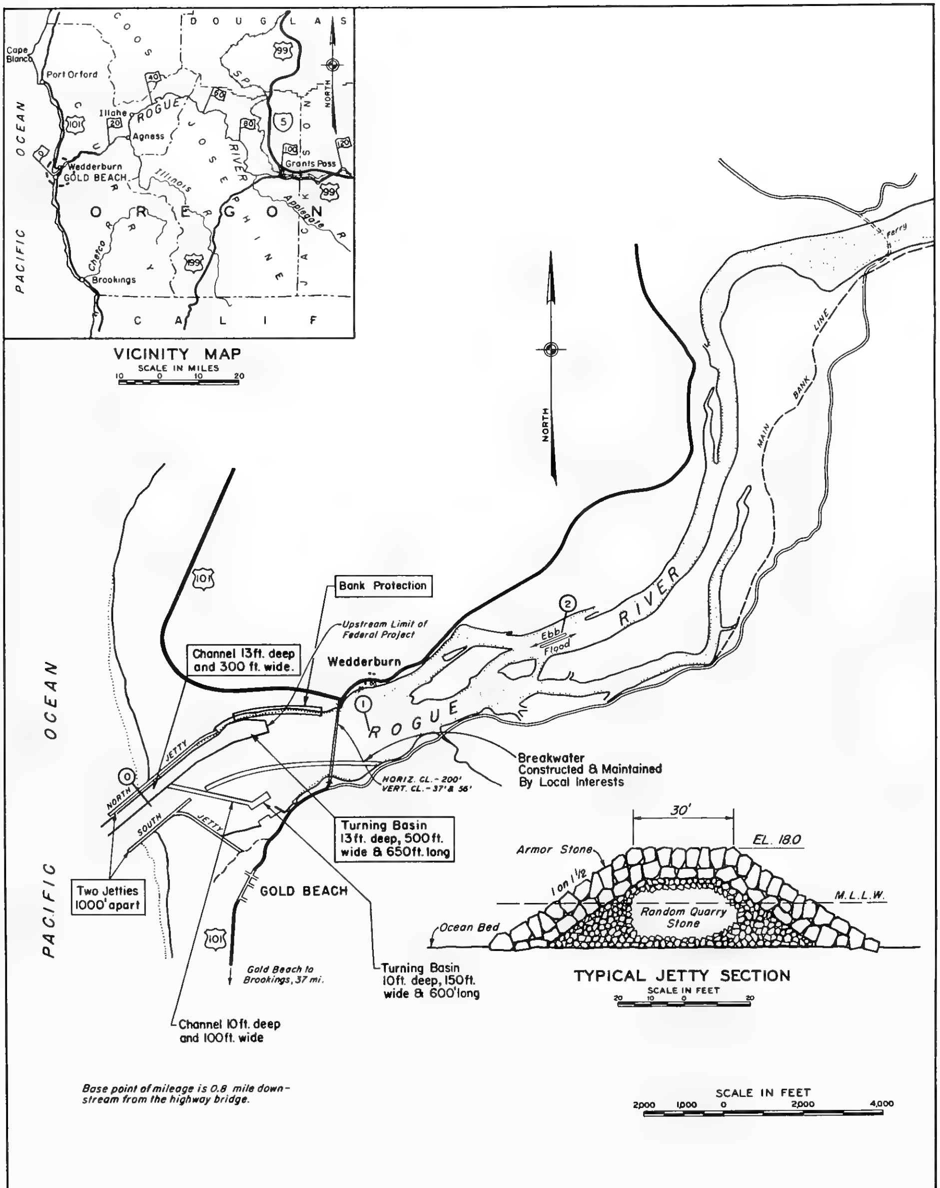

Figure 59. Site layout at Rogue River, Oregon (revised 1977)

Table 29

Siuslaw River

Florence, Oregon

Date(s)	Construction and Rehabilitation History
1890	The original project was authorized.
1891	The original project was modified. The project included a 10-ft channel maintained by two high-tide rubble-mound jetties that were 600 ft apart at the ends. The north jetty was 7,500 ft long; the south jetty was 5,600 ft long.
1893	Construction began on the north jetty.
1905	The project was suspended. The north jetty had been constructed to 4,090 ft, and work had not been started on the south jetty.
1910	The existing project was adopted. The project included an 8-ft-deep bar channel maintained by two high-tide rubble-mound jetties that were 750 ft apart at the ends. The north jetty would be extended by 3,700 ft, and the south jetty would be 4,200 ft long.
1912	Work on the jetties was suspended.
1916-1917	The south jetty was repaired and extended.
1917	The jetties were completed. The north jetty was 7,490 ft long and included 441,237 tons of stone. The south jetty was 3,945 ft long and used 196,860 tons of stone. Both jetties had crest elevations of +15 ft mllw, crest widths of 15 to 20 ft, and side slopes of 1:1.5 to 1:2.
1955	The south jetty had been deteriorating since 1917. Deterioration accelerated in 1955 when a portion of the jetty near shore that had been constructed in 1912 was exposed.
1957	The north jetty was repaired. Class "A" armor stone used were over 6 tons each and averaged 10 tons. Class "B" stone was over 1 ton and averaged 3 tons.
1958	The 600-ft extension to the north jetty was approved but deferred.
1961	The outer 300 ft of the south jetty was at mllw. The crest of the rest of the jetty varied from +5 to +10 ft mllw.
1969	An aerial photograph of the jetties taken in 1969 is presented in Figure 60.

(Continued)

Table 29 (Concluded)

Date(s)	Construction and Rehabilitation History
1981	The 2,000-ft extension to the north jetty and the 2,500-ft extension to the south jetty were approved. The north jetty extension included the 600-ft extension authorized in 1958.
1983-1985	The jetties were extended. A 756-ft length of the north jetty was rehabilitated, and the jetty was extended 2,500 ft. The south jetty was extended about 2,300 ft. Four spur "wings", each 100 ft long, were constructed at a 45-deg angle near the end of each jetty. The project required 1,300,000 tons of rock. Crest elevations of the extensions were +18 ft mllw, except for the seaward 300 ft of the north jetty and the seaward 500 ft of the south jetty, which had crest elevations of +20 ft mllw. Crest elevation of the spurs varied from +18 ft to +14 ft mllw. The top width of the extensions was 34 ft, and the side slopes were 1:2 above mllw and 1:1.5 below mllw. Armor layer thickness was typically 14 ft on the extensions, using class "A" stone weighing between 11.5 and 18.9 tons and averaging 15 tons. Select class "A" stone weighing a minimum of 19 tons was used for the armor layer near the end of each extension. Stone weights were based on a unit weight of 165 pcf.
1985	The harbor and cross sections of the jetties are illustrated in Figure 61. Both jetties are in good condition at this time.

Figure 60. Aerial photograph of jetties at Siuslaw River, Oregon, 1969

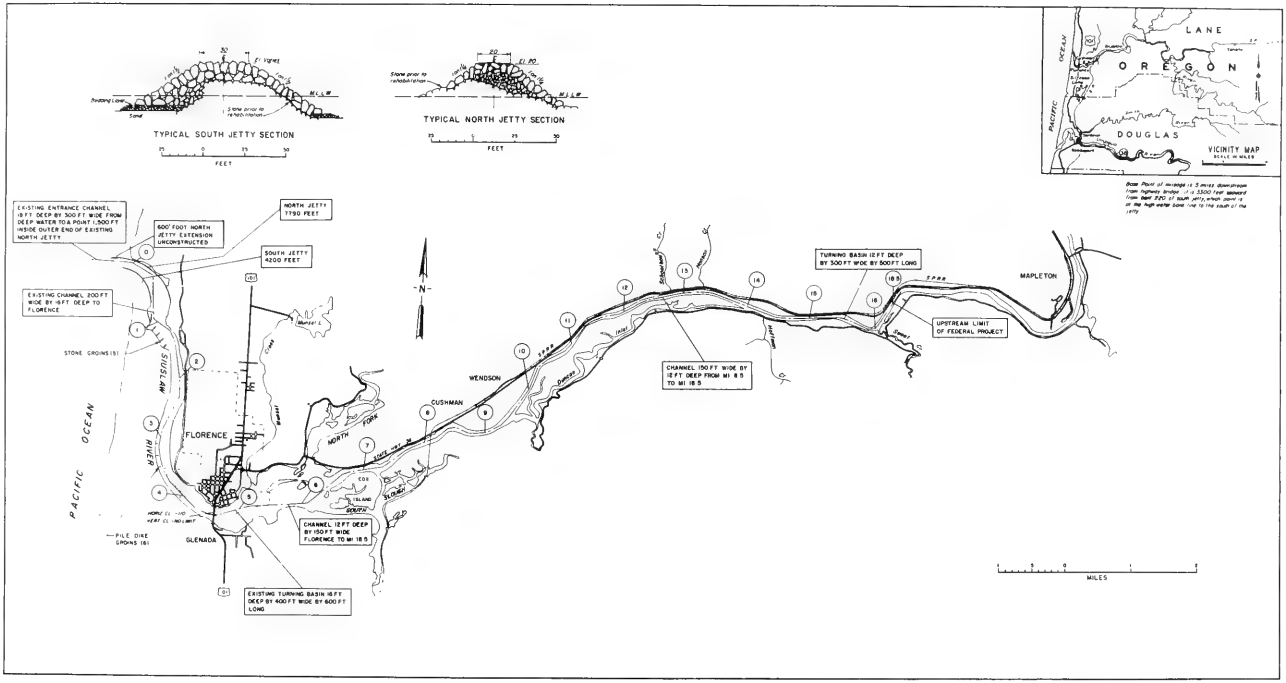

Figure 61. Site layout of Siuslaw River, Oregon

Table 30

Tillamook Bay

Tillamook, Oregon

Date(s)	Construction and Rehabilitation History
1912	The north jetty was authorized to 5,700 ft.
1914-1917	The north jetty was constructed to 5,400 ft using 428,672 tons of rock.
1921	The north jetty was repaired with 500 tons of rock placed near the shore end of the structure.
1931-1933	The north jetty was reconstructed and extended to the full authorized length of 5,700 ft, requiring 320,350 tons of rock.
1946	Minor repairs were made to the shore end of the north jetty.
1955	Repairs were made to the north jetty near the shore end. Also, a breach at the beachline of the north jetty that had been cut to bring a beached vessel through the jetty was repaired. Repair work used 5,535 tons of rock. A 1955 aerial photograph of the north jetty is given in Figure 62.
1962	The beach was built up on the north side of the jetty for 3,500 ft. Seaward of the beachline, the jetty crest was at half tide and the outer 800 ft was below the low water level.
1963-1965	The north jetty was rehabilitated. The jetty was raised to a crest elevation of +18 ft mllw from sta 32+60 to 53+00 then increased to +24 ft mllw between sta 53+00 and 55+00, and remaining at +24 ft to sta 57+00. Design wave for the rehabilitation varied from a 16.5-ft breaking wave nearshore to a 23.5-ft breaking wave at the head. The work required an estimated 174,000 tons of class "A", "B", and "C" stone, plus 60,000 tons of select class "A" stone. Select class "A" had a minimum weight of 18 tons, class "A" had a minimum weight of 12 tons and an average weight of 15 tons, and class "B" had a minimum weight of 5 tons and an average weight of 8 tons. At least 57 percent of the weight was class "A".
1965	The south jetty was authorized to 8,000 ft.
1969-1971	The south jetty was constructed to 3,695 ft. The contract was for construction of the first 5,000 ft of the jetty, but overruns caused by scour in front of the construction caused the work to be suspended. The work required 655,049 tons of stone.
1972-1974	The south jetty was extended by 2,830 ft, requiring 783,944 tons of stone. The distance between the north and south jetties was reduced from 1,400 ft to 1,200 ft.

(Continued)

Table 30 (Concluded)

Date(s)	Construction and Rehabilitation History
1978-1979	The south jetty was extended to 8,000 ft.
1985	The harbor and cross sections of the jetties are illustrated in Figure 63. The head of the north jetty has received some damage from extreme wave conditions, and the outer portion of the south jetty has shown some subsidence. No repairs or rehabilitation are planned at this time.

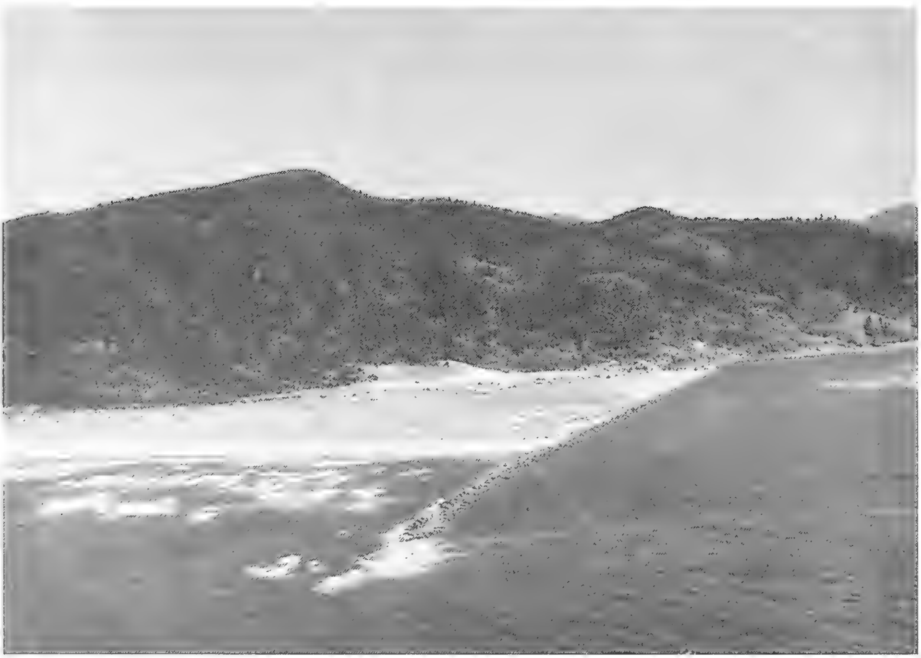

Figure 62. Aerial photograph of north jetty, Tillamook Bay, Oregon, 1955

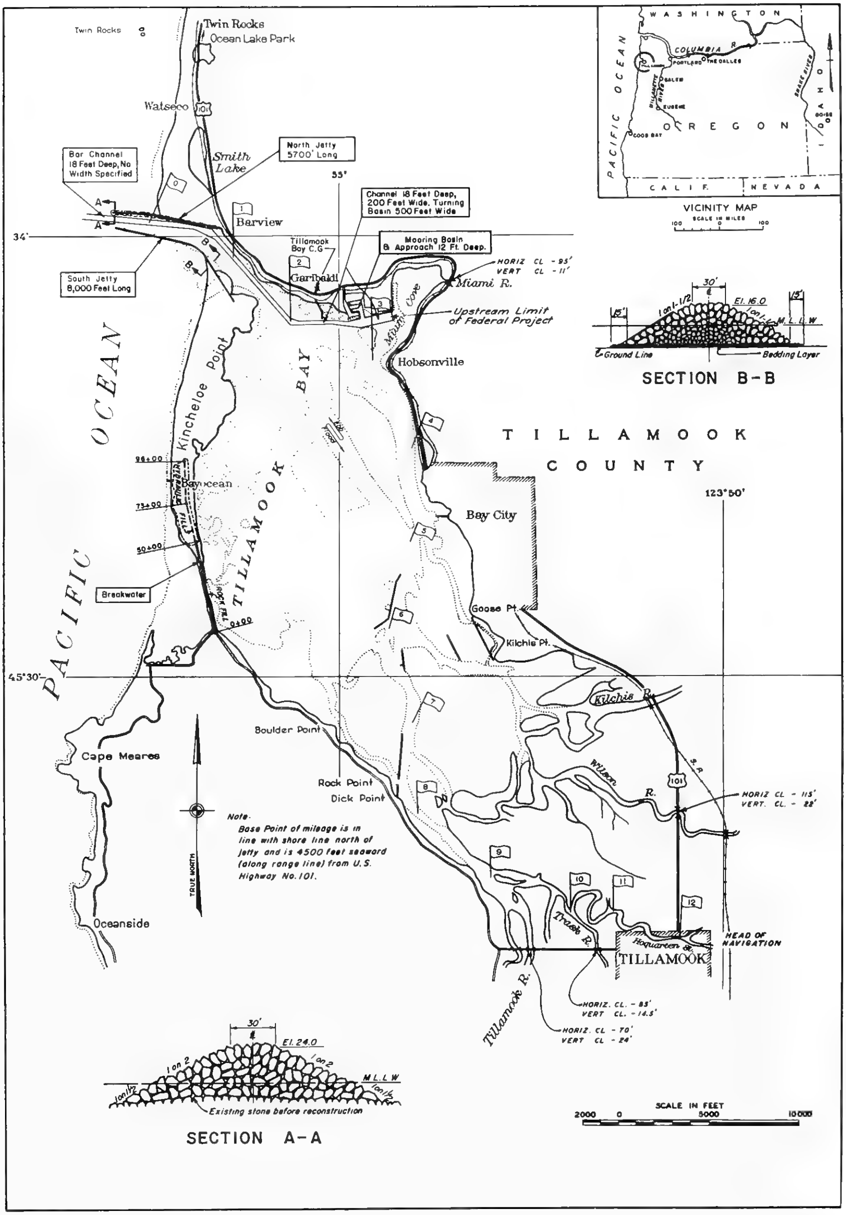

Figure 63. Site layout at Tillamook Bay and Bar, Oregon (revised 1979)

Table 31

Umpqua River

Reedsport, Oregon

Date(s)	Construction and Rehabilitation History
1916-1919	Local interests constructed the north jetty to 3,390 ft.
1922	The project was adopted for extending the north jetty to 7,500 ft.
1923-1926	The north jetty was extended to 6,495 ft. The project was suspended due to lack of funds.
1928-1930	The north jetty was extended to 8,000 ft.
1930	The short south jetty was authorized.
1931	The north jetty maintenance work required 35,752 tons of stone.
1933-1934	The south jetty was constructed.
1935	The 1,700-ft extension to the south jetty was authorized.
1937-1938	The south jetty extension was completed, terminating in a monolithic concrete block 46 ft long by 30 ft wide by 16 ft high, flanked by four wing blocks each 18 ft long by 14 ft wide by 8 ft high and two end blocks each 20 ft long by 14 ft wide by 8 ft high.
1940	The shore end of the south jetty was extended 550 ft to high ground. The seaward end of the south jetty was beaten down or settled into a sand base to mlw for about 400 ft.
1941	The seaward 1,000 ft of the south jetty was beaten down or settled into the sand base to mlw.
1941-1942	The outer 4,000 ft of the north jetty was rehabilitated with 90,358 tons of stone, and a concrete cap was placed on the outer 3,977 ft of jetty, requiring 28,291 cu yd of concrete. The crest of the concrete cap was at elevation +14 ft mllw.
1946-1948	The hydraulic model study at WES recommended construction of a training jetty.
1950-1951	The training jetty (4,240 ft long) was constructed parallel to and along the south side of the entrance channel.

(Continued)

Table 31 (Concluded)

Date(s)	Construction and Rehabilitation History
1963	The south jetty was rehabilitated. The crest elevation varied, but it was +26 ft mllw at the head. The crest width was 26 ft, and side slopes were 1:2 above mllw on the ocean side but 1:1.5 elsewhere.
1964	The hydraulic model study at WES recommended extension of the training jetty.
1977	The north jetty was rehabilitated. The crest elevation was raised to +20 ft mllw with a crest width of 28 ft and side slopes of 1:1.5 on the channel side. Side slopes on the ocean side were 1:2 above mllw and 1:1.5 below mllw. The head of the jetty was at elevation +21 ft mllw with a crest width of 28 ft and side slopes of 1:2 above mllw and 1:1.5 below mllw.
1978-1980	The training jetty extended to the end of the south jetty. The extension had a crest elevation of +14 ft mllw, a crest width of 30 ft, and side slopes of 1:1.5. The core stone was covered with armor stone to elevation -10 ft mllw. The armor layer was 12 ft thick on the channel side and on the crest and 6 ft thick on the side of the embayment between the training jetty and the south jetty.
1985	The harbor and cross sections of the jetties are illustrated in Figure 64. The jetties appear in good condition at this time.

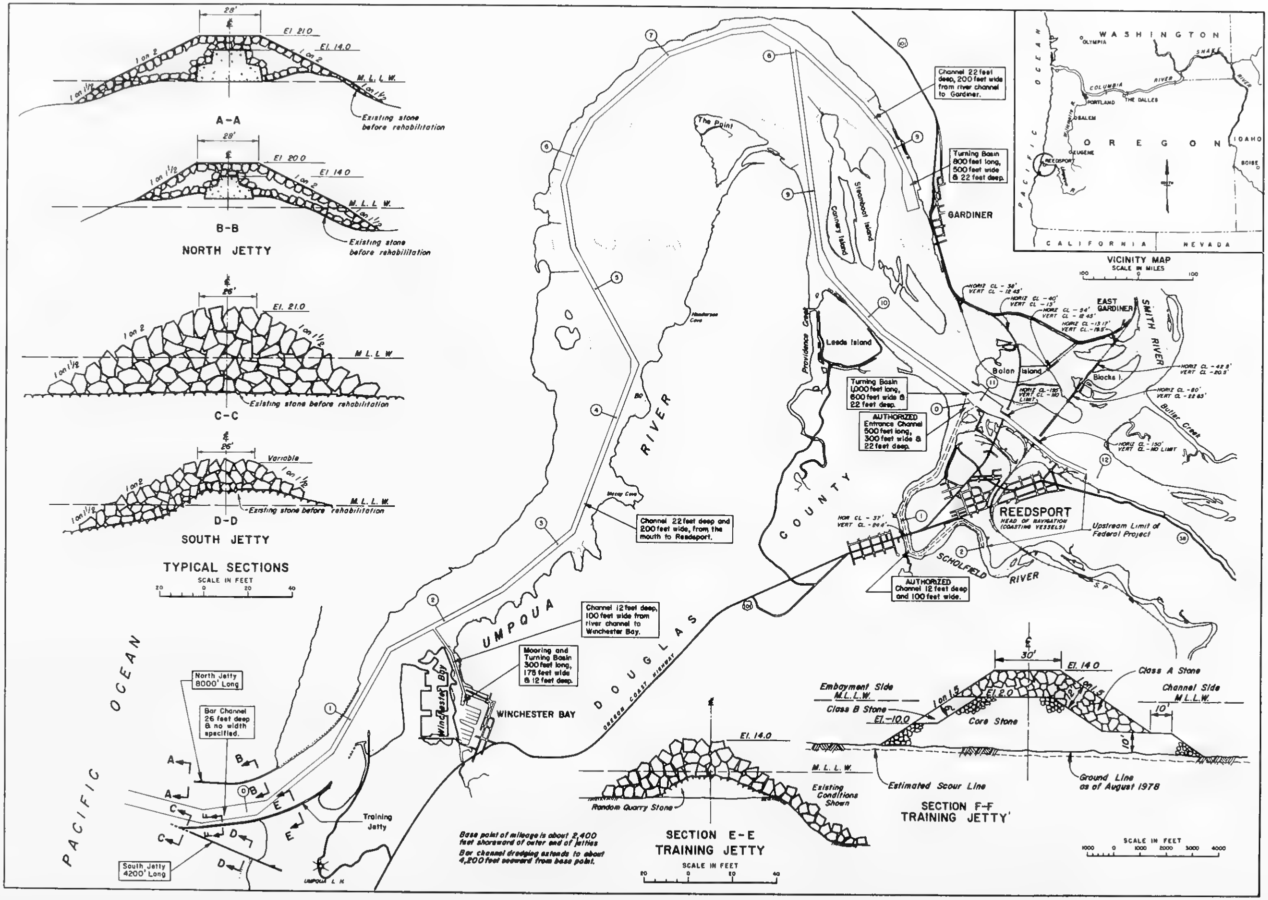

Figure 64. Site layout at Umpqua River, Oregon (revised 1981)

Table 32

Yaquina Bay

Newport, Oregon

Date(s)	Construction and Rehabilitation History
1880	The original project was authorized.
1895	The original project was completed, including two high-tide rubble-mound jetties. The north jetty was 2,300 ft long, the south jetty was 3,600 ft long, and the ends were separated by 1,000 ft.
1919	Restoration and extension of the jetties was authorized.
1921	An extension of the south jetty to 5,800 ft was completed. An 800-ft spur dike and 5 groins were added to the channel side of the south jetty.
1930	An extension of the north jetty to 3,700 ft was completed.
1933-1934	The outer 2,200 ft of the north jetty and 2,700 ft of the south jetty were restored to project heights. The estimated stone required was 47,000 tons of class "A" and 23,000 tons of class "B" and "C" combined for the north jetty, and 62,000 tons of class "A" and 48,000 tons of class "B" and "C" combined for the south jetty. Class "A" stone averaged 9 tons with a minimum weight of 6 tons; class "B" stone averaged 2.5 to 3 tons with a minimum weight of 1 ton. Stone was placed by dumping from a tramway.
1937	A 1,000-ft extension of the north jetty was authorized.
1939-1940	The north jetty was rehabilitated and extended 1,000 ft. The work required an estimated 180,000 tons of stone and 6,018 cu yd of concrete for a terminal cap. Class "A" stone weighed between 6 and 25 tons and averaged 10 tons, and class "B" stone weighed between 1 and 6 tons and averaged 2.5 to 3 tons. Stone was placed by dumping from a tramway.
1948	Two breakwaters were constructed for a small-boat basin at Newport. The detached breakwater was 2,650 ft long, and the shore wing was 400 ft long. Both jetties were timber, pile, and stone construction to +14 ft mllw. A cross section of the breakwaters is given in Figure 65.
1956	The north jetty was rehabilitated using an estimated 220,000 tons of stone. Class "A" stone weighed more than 6 tons and averaged 10 tons; class "B" stone weighed between 1 and 6 tons and averaged 3 tons. The stone was placed by dumping from a hauling vehicle. Select class "A" stone weighing up to 20 tons was used for the terminus.

(Continued)

Table 32 (Concluded)

Date(s)	Construction and Rehabilitation History
1958	An extension of the north and south jetties was authorized.
1966	The north jetty was extended to 7,000 ft. The crest elevation was +20 ft mllw, crest width was 30 ft, side slopes were 1:2 above mllw and 1:1.5 below mllw. Stone weights, based on 165 pcf, were a minimum of 20.5 tons for select class "A", a minimum of 13.5 tons and an average of 17 tons for class "A", and a minimum of 5.5 tons and an average of 9 tons for class "B". The work required 80,904 tons of select class "A" stone, 274,243 tons of class "A" stone, 192,612 tons of class "B" stone, 116,296 tons of class "C" stone, and 125,024 tons of bedding material. Stones used in the armor layer were individually placed by crane.
1970-1972	The south jetty was extended to 7,600 ft. The crest elevation was +20 ft mllw, crest width was 30 ft, and side slopes were 1:2 above mllw and 1:1.5 below mllw. Stone weights, based on 170 pcf, were a minimum of 22 tons for select class "A", a minimum of 12 tons and an average of 17 tons for class "A", and a minimum of 6 tons and an average of 9 tons for class "B". Estimated quantities were 66,500 tons of select class "A", 179,300 tons of class "A", 184,000 tons of class "B", 69,700 tons of class "C", and 79,500 tons of bedding material. Stone in the armor layer was individually placed by crane. The design wave was a breaking wave varying in height along the jetty from 18.5 to 27 ft.
1976	Rehabilitation of the north jetty was authorized.
1977-1978	The outer 500 ft of the north jetty were repaired. The north jetty was sand sealed by blasting between stations 46+00 and 66+00.
	The small-boat basin was constructed at South Beach, Oregon, including two high-tide rubble-mound breakwaters with lengths of 1,800 and 700 ft. The breakwaters were designed for a 3-ft wave and a still-water level of +9 ft mllw. Crest elevation was +14 ft mllw with a crest width of 10 ft and side slopes of 1:1.5. The work required an estimated 11,500 cu yd of armor stone, 35,700 cu yd of core and bedding stone for the breakwaters, plus 2,000 cu yd of quarry spalls and 3,000 cu yd of gravel bedding for shore protection. Armor stone weight was between 100 and 1,000 lb, with at least 50 percent of the pieces weighing more than 300 lb.
1983	The outer 360 ft of the north jetty subsided to below water surface and required major rehabilitation.
1985	The harbor and cross section of the jetties are illustrated in Figure 65. The south jetty shows some damage but is serviceable, and no repairs are planned at this time. Studies are currently being conducted for major rehabilitation of the north jetty.

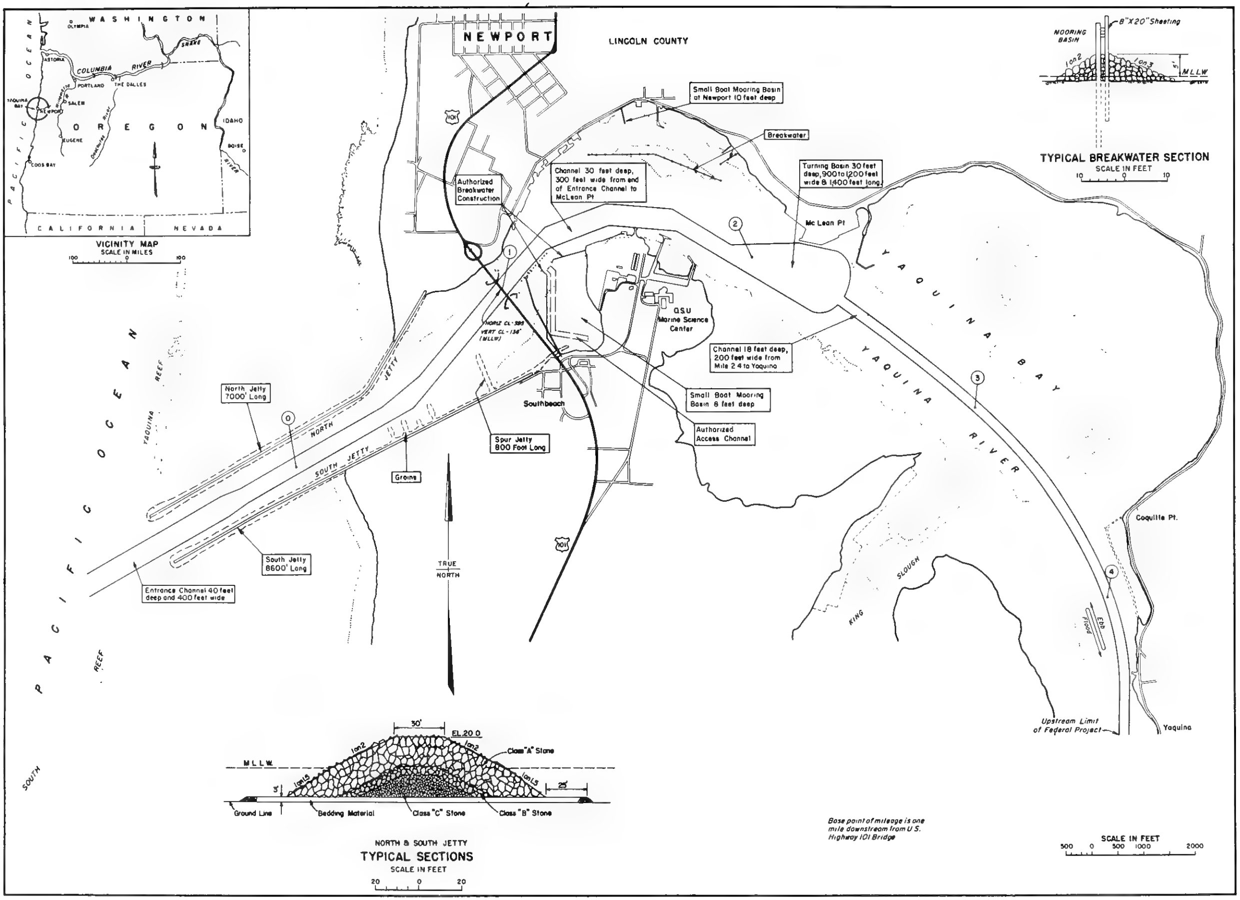

Figure 65. Site layout at Yaquina Bay and Harbor, Oregon (revised 1978)

Table 33

Anacortes Harbor

Anacortes, Washington

Date(s)	Construction and Rehabilitation History
1919	The channel project was completed.
1954	The project was modified to include the boat basin and two pile breakwaters. The project originally called for just the 370-ft-long southeast breakwater. The south side of the harbor was protected by log booms owned by a local mill. With the closure of the mill, the log booms were removed, and the south breakwater (350 ft) was required.
1957	Construction of the pile breakwaters was completed. The breakwaters were constructed of treated timber pilings that were 14 in. in diameter, with a minimum penetration of 16 ft, reinforced with 8- by 10-in. wales. A seven-pile dolphin was constructed at the Capsante Waterway end of each breakwater. A cross section of the breakwaters is shown in Figure 66.
	During a storm in November 1957, the breakwaters were seen to provide inadequate protection against storms from the southeast. The breakwaters left a 100-ft wide channel for the Capsante Waterway.
1958	The Seattle District and the North Pacific Division recommended extension of the breakwaters, but federal funds were unavailable. The Port of Anacortes therefore extended the south breakwater to 440 ft (total length).
1964	Both breakwaters were extended to 470 ft. The extensions were in the Capsante Waterway. To provide greater stability in the deeper waters of the waterway, the toes of the extensions were protected by a rock cover with a gravel and spalls blanket to a depth of -6 ft mllw and a top width of 8 ft.
1976	Both breakwaters were rehabilitated by cleaning and treating the pile heads or replacing the piles.
1982	The mooring basin was enlarged by the Port of Anacortes.
1985	The harbor is illustrated in Figure 66. There have been no reports of needed repairs or rehabilitation since 1976.

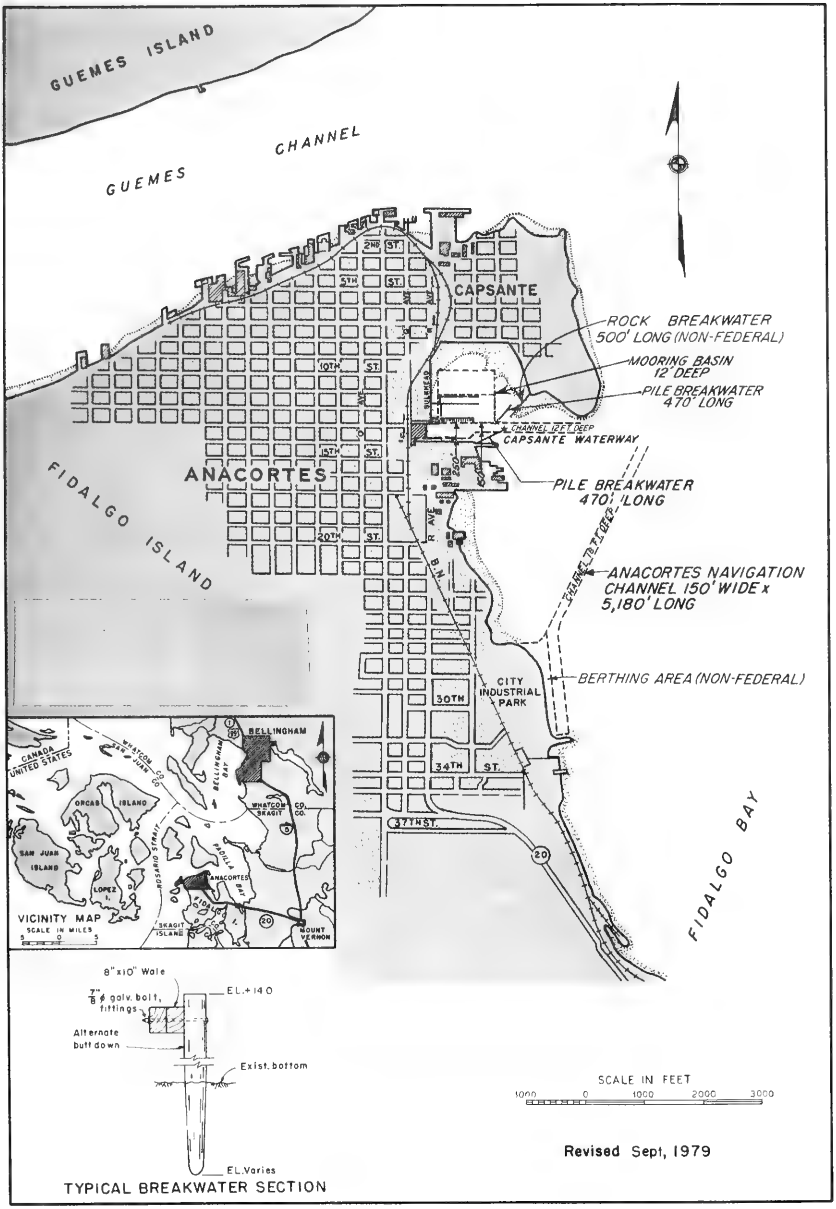

Figure 66. Site layout of Anacortes Harbor, Washington (revised 1979)

Table 34

Bellingham Harbor

Bellingham, Washington

Date(s)	Construction and Rehabilitation History
1954	The small-boat basin was authorized, including construction of two rubble-mound breakwaters with a combined length of 3,900 ft and removal of a 1,400-ft-long rubble-mound breakwater constructed by the Port of Bellingham in 1934.
1958	Construction of a small-boat basin was completed. The breakwaters were constructed on a gravel mat to compensate for poor foundation conditions.
1960	The River and Harbor Act authorized harbor expansion.
1980	Harbor expansion was completed, including construction of a 1,500-ft rubble-mound breakwater.
1985	The harbor and cross sections of the breakwaters are shown in Figure 67. There are no reports of needed repairs or rehabilitation for the breakwaters.

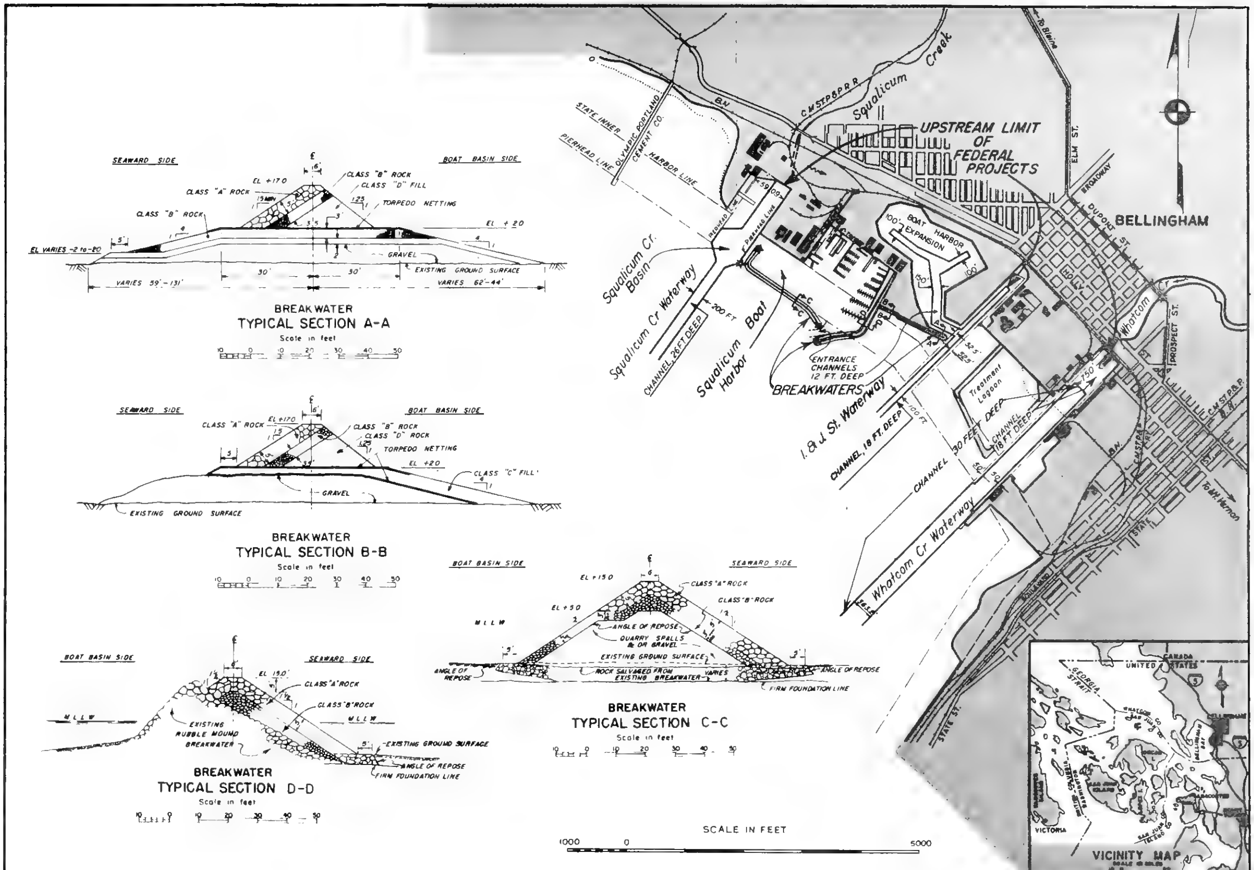

Figure 67. Site layout of Bellingham Harbor, Washington (revised 1982)

Table 35

Blaine Harbor

Blaine Harbor, Washington

Date(s)	Construction and Rehabilitation History
1936	Local interests dredged the initial boat basin.
1936-1956	The boat basin was expanded several times by local interests.
1950	The project document was prepared.
1954	The project was authorized, including dredging an additional 14.7 acres to a depth of -12 ft mllw, construction of a 1,500-ft rubble-mound breakwater to a height of +15 ft mllw with side slopes of 1:1.5, and repair of an existing 450-ft rubble-mound breakwater. The planking and bracing of an existing 834-ft two-step untreated wood pile and rock breakwater were removed, and the breakwater was rebuilt as a rubble-mound breakwater.
1957	The project was completed.
1985	The harbor and cross sections of the breakwater are illustrated in Figure 68. Since completion of the breakwater, local interests have built and maintained additional pile breakwaters at the entrance to the harbor. There have been no reports of needed repairs or rehabilitation for the Corps maintained structures.

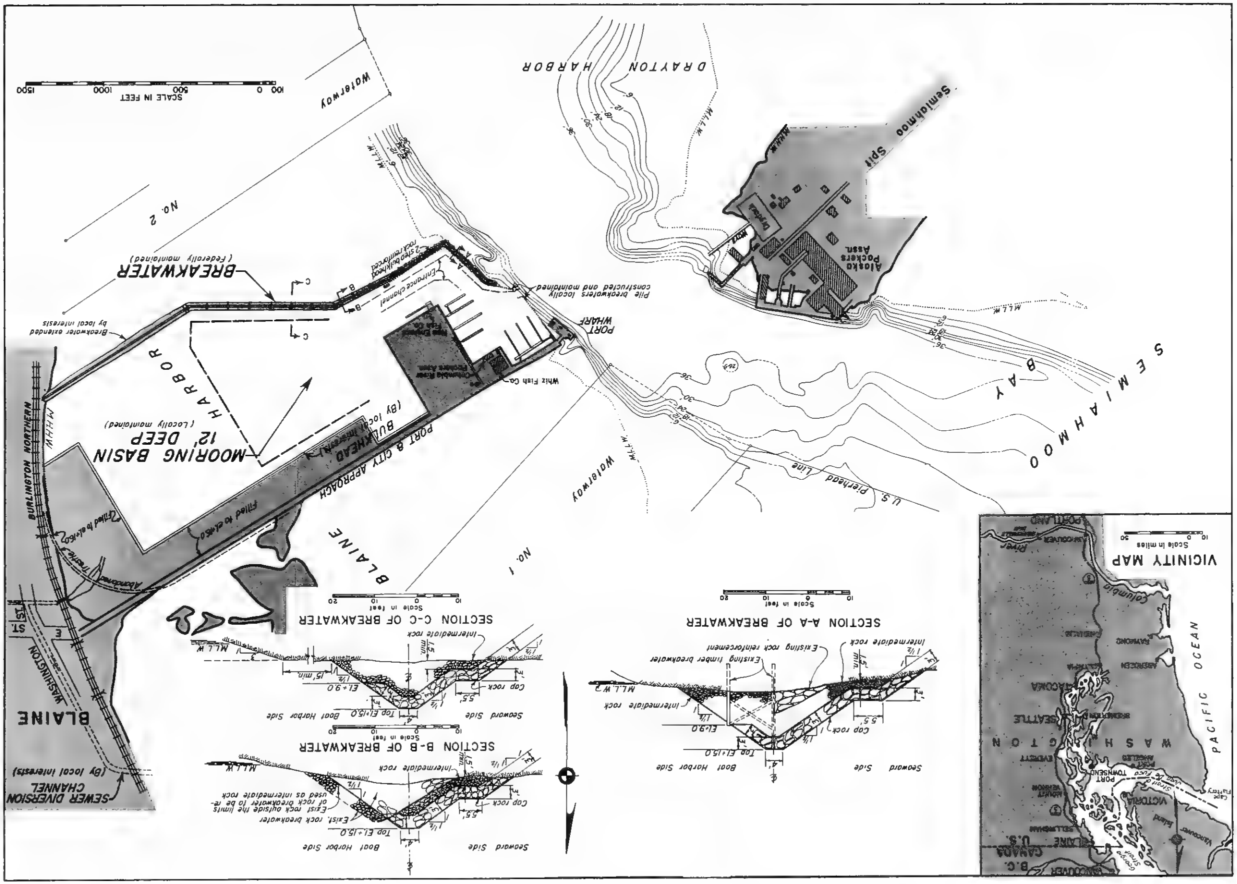

Figure 68. Site layout at Blaine Harbor, Washington (revised 1972)

Table 36

Edmonds Harbor

Edmonds, Washington

Date(s)	Construction and Rehabilitation History
1962	The harbor was constructed by local interests, including a 1,850-ft rubble-mound breakwater with a crest elevation of +18.5 ft mllw and a 250-ft rock reinforced treated pile and plank breakwater.
1965	The Corps accepted maintenance of the two breakwaters and an entrance channel 610 ft long by 65 ft wide by 13 ft deep mllw.
1968	The basin was extended by local interests. The basin extension is maintained by local interests.
1985	The harbor and cross sections of the breakwaters are illustrated in Figure 69. The Corps maintained structures are surveyed annually. There are no records of any repairs or maintenance work.

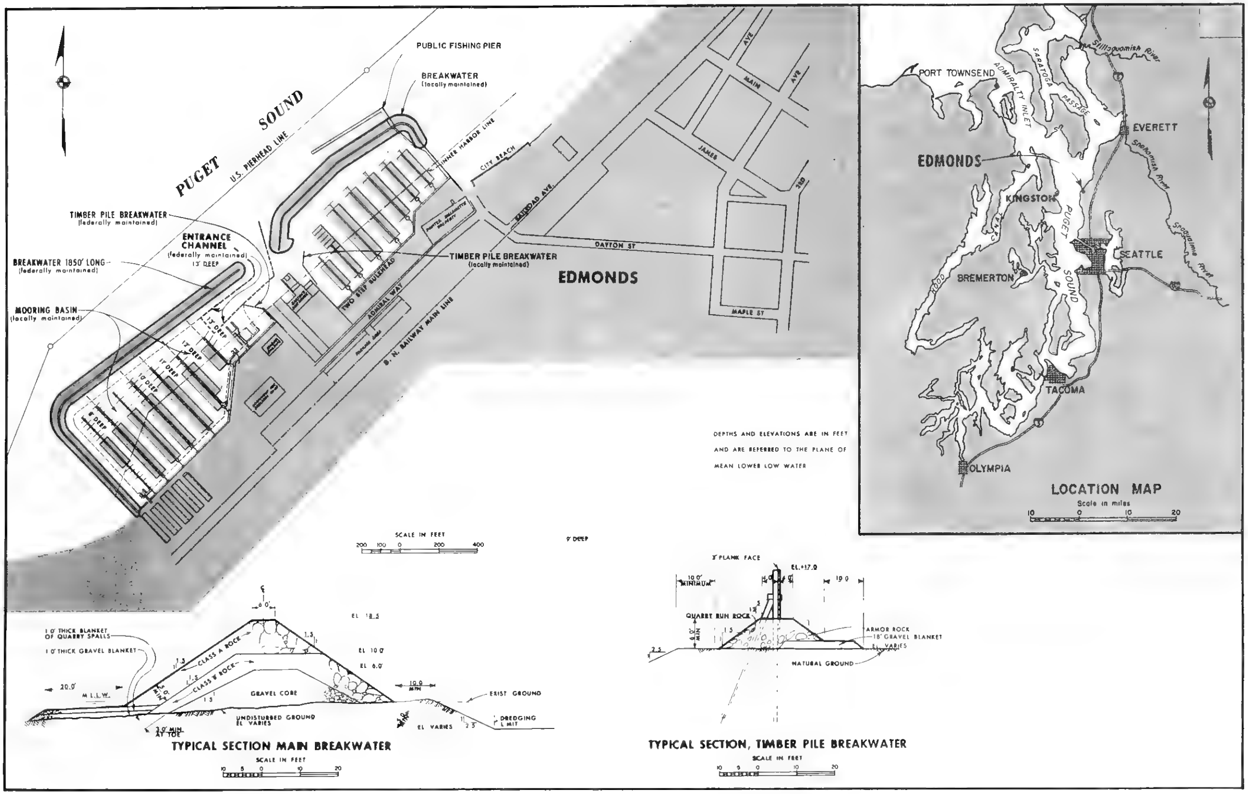

Figure 69. Site layout at Edmonds Harbor, Washington (revised 1979)

Table 37

Gray's Harbor

Gray's Harbor, Washington

Date(s)	Construction and Rehabilitation History
1896	The Rivers and Harbor Act authorized construction of a single jetty extending 18,000 ft seaward from the southerly peninsula at the mouth of Gray's Harbor.
1898	Construction of the south jetty commenced.
1898-1904	Point Chehalis shoreline accreted and moved westerly a maximum of 3,000 ft just south of the jetty.
1902	The south jetty was completed to a height of +8 ft mllw and a total length of 13,734 ft, of which 11,950 ft extended seaward of the high waterline. During construction, the adjacent channel undermined the structure causing material overruns which depleted project funds before the design length of 18,000 ft could be obtained. A groin was constructed 11,952 ft from the high waterline.
1906	Construction of the north jetty to a height of mean sea level (+5 ft mllw) and a length of 9,000 ft was authorized.
1907	Construction of the north jetty commenced.
1910	The north jetty was completed to a length of 10,000 ft. An extension of 7,000 ft was authorized.
1913	The north jetty was completed to a midtide elevation of +5 ft mllw with a total length of 16,000 ft.
1916	The north jetty was restored to +8 ft mllw.
1933	By 1933, the south jetty had subsided to +6 ft mllw at the shoreward end and -10 ft mllw at the outer end.
1935	Reconstruction of the north and south jetties was authorized.
1936-1939	A 12,656-ft section of the south jetty was reconstructed to an elevation of +20 ft. The reconstruction blocked the supply of sand to Point Chehalis, causing serious erosion. A 32-ft section of the jetty was removed to try to restore the supply of sand, but it was quickly blocked by accretion south of the jetty.
1939-1946	The outer 900 ft of the south jetty was destroyed, and crest rock was displaced over the next 2,656 ft.

(Continued)

Table 37 (Concluded)

Date(s)	Construction and Rehabilitation History
1940	The inner 7,300 ft of the north jetty, shoreward of the high waterline, had sanded in.
1941-1942	The north jetty was reconstructed to +20 ft mllw for 7,760 ft seaward of the high water shoreline, then +30 ft mllw for an additional 528 ft. The 412 ft seaward of the reconstructed section was at mllw and was not restored.
1942-1949	The outer 325 ft of the north jetty was leveled, and 400 ft of the reconstructed section was lowered 4 ft below grade.
1946-1951	An additional 900 ft of south jetty was destroyed, and the next 4,100 ft subsided 10-20 ft below grade.
1949-1953	An additional 325 ft of north jetty was leveled, and a 1,000-ft section was lowered to 10 ft below grade.
1950-1952	A hydraulic model study was conducted by WES.
1951-1953	An additional 900 ft of south jetty was destroyed, and the next 4,500 ft subsided to 18-20 ft below grade.
1953-1962	An additional 1,700 ft of south jetty subsided to depths of approximate mllw, leaving less than 5,000 ft of the jetty near grade.
1961	Only 2,000 ft of the reconstructed portion of the north jetty remained at or near grade.
1966	The south jetty (4,000 ft) was reconstructed to +8 ft mllw.
1969-1971	A hydraulic model study of Gray's Harbor was conducted.
1975-1976	A 6,000-ft length of the north jetty was rehabilitated.
1985	The harbor and cross sections of the jetties are illustrated in Figure 70. The outer 1,200 ft of the north jetty and 5,600 ft of the south jetty are submerged. There is some deterioration of the south jetty, with severe scour along the channel side toe of the jetty. The overtopping conditions on the north jetty in the area of the 1975 rehabilitation work threatens a roadway on the land side of the jetty.

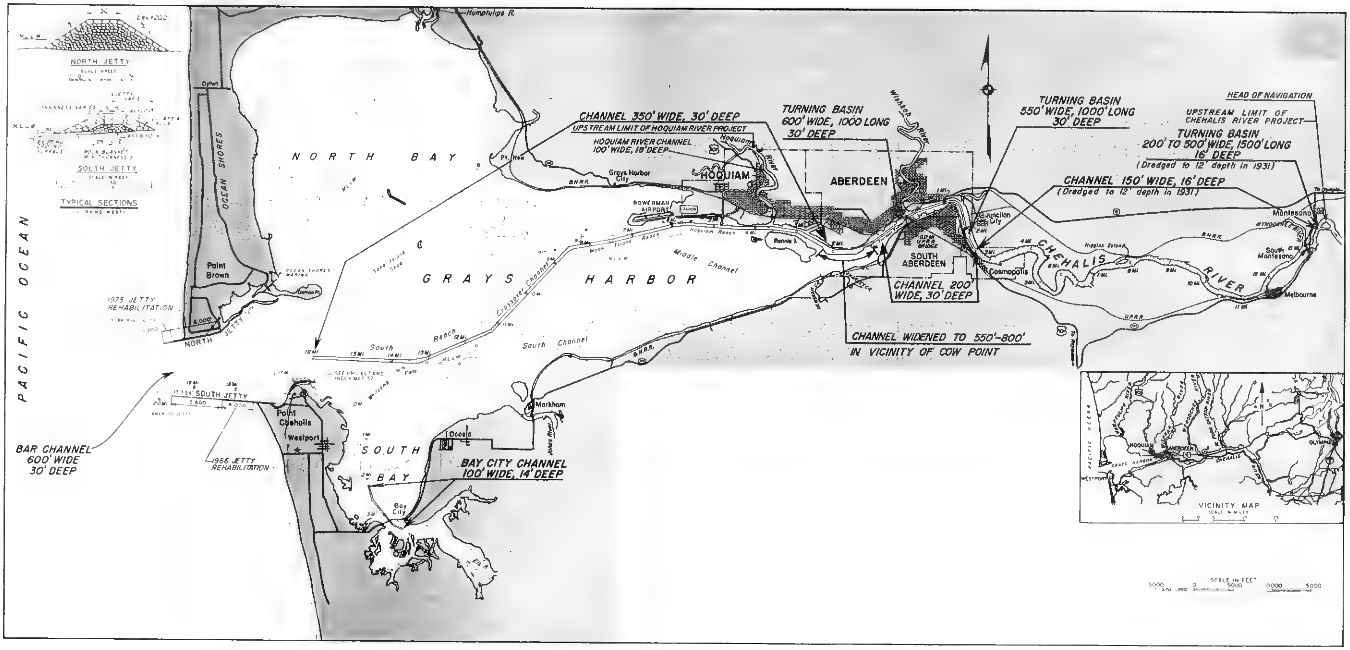

Figure 70. Site layout of Gray's Harbor, Washington

Table 38

Kingston Harbor

Kingston, Washington

Date(s)	Construction and Rehabilitation History
1962	The project was adopted.
1967	The breakwater was constructed. The breakwater is rubble mound with a gravel or quarry spall core, top elevation of +19 ft mllw, crest width of 7.5 ft, length of 1,040 ft, and side slopes of 1:1.5. The shoreward end of the breakwater was tied into a vertical sheet-pile retaining wall of an existing ferry dock approach fill. Wave reflection off the retaining wall increased the wave action at the landward end of the breakwater. The landward 50 ft of the breakwater was therefore built to an elevation of +20 ft mllw.
1985	The harbor and cross section of the breakwater are illustrated in Figure 71. There are no reports of needed repairs or rehabilitation.

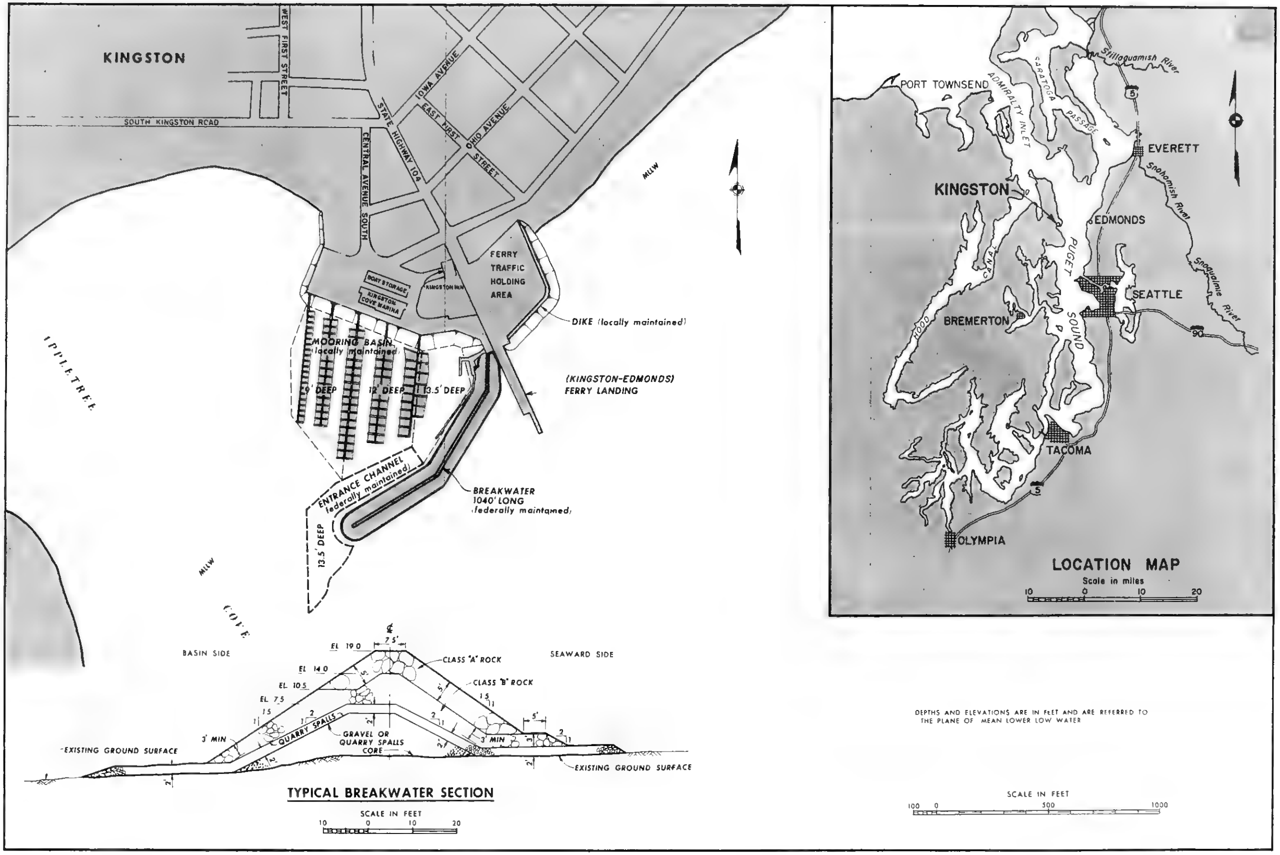

Figure 71. Site layout at Kingston Harbor, Washington (revised 1979)

Table 39

Lake Crockett

Whidbey Island, Washington

Date(s)	Construction and Rehabilitation History
1945	The project was adopted.
1947-1948	The project was constructed, including 28,000 tons of rock for a breakwater, and the basin and entrance channel were dredged.
1950	The breakwater was repaired.
1954	The breakwater was repaired with 700 tons of rock.
1960	The breakwater was restored to design height and lengthened 175 ft, and an easterly spur was added for protection against southeasterly storms. The repair work required 871 tons of rock for the breakwater plus 505 tons of quarry spalls. An additional 606 tons of quarry rock were added to a revetment.
1971	The entrance channel was widened to 200 ft to reduce the frequency of dredging.
1985	The harbor and cross section of the breakwater are illustrated in Figure 72. No repairs or rehabilitation to the structure have been recorded since 1960.

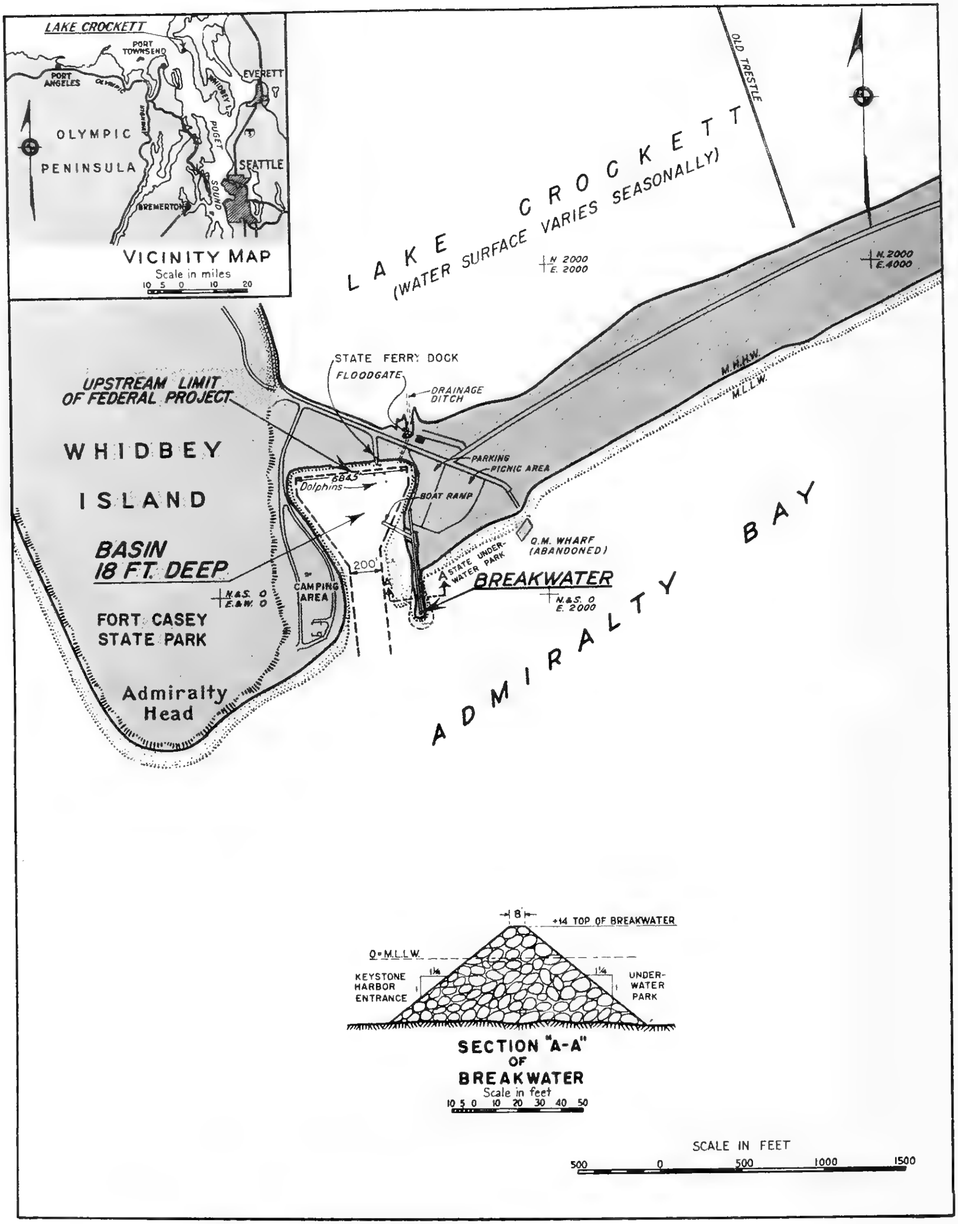

Figure 72. Site layout at Lake Crockett, Washington (revised 1979)

Table 40

Neah Bay

Neah Bay, Washington

Date(s)	Construction and Rehabilitation History
1938	The breakwater was authorized.
1941-1944	The breakwater was constructed, and it required 1,195,280 tons of stone, with an average armor stone weight of 4 tons.
1948	In October the breakwater was damaged by a storm. In November the worst storm in 27 years caused extensive damage to the breakwater. The storm caused 10 breaks ranging in length from 32 to 175 ft and descending to about elevation +4 ft mllw. The storm caused serious damage to the coast guard dock, damaged 7 homes, and destroyed a bulkhead. Waves passing between Waada Island and Baada Point reached heights of 20 ft.
1949	The breakwater was repaired by salvaging and replacing 2,500 tons of displaced stone and placing an additional 15,500 tons with an average weight of 4 tons. The rock quantities are from the design estimate.
1959	The breakwater was repaired with 7,000 tons of armor rock with an average weight of 6 tons.
1980	The westerly 4,200 ft of the breakwater was rehabilitated. The design specified a crest elevation of +18 ft mllw including a 5-ft-thick single layer armor rock protective cap. The crest width was 25 ft, and side slopes were 1:1.5.
1985	The harbor and cross section of the breakwater are illustrated in Figure 73. The breakwater appears in good condition at this time.

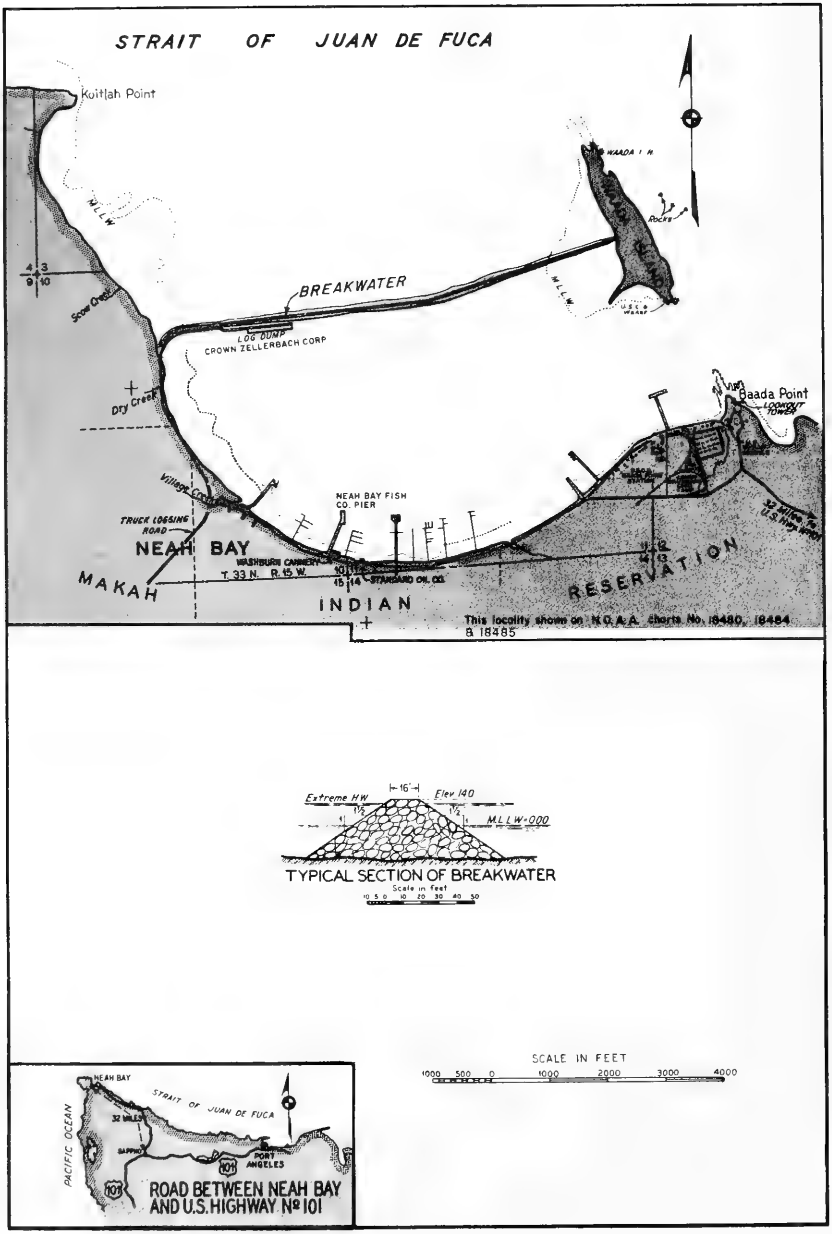

Figure 73. Site layout at Neah Bay, Washington (revised 1979)

Table 41

Olympia Harbor

Olympia, Washington

Date(s)	Construction and Rehabilitation History
1974	A preliminary investigation for the small-boat basin was requested by the Port of Olympia.
1980	The final project report on East Bay Marina was completed.
1983	Construction of the 656-ft-long floating concrete breakwater was completed in East Bay Marina.
1985	The harbor and cross section of the breakwater are illustrated in Figure 74. No repairs or rehabilitation are necessary.

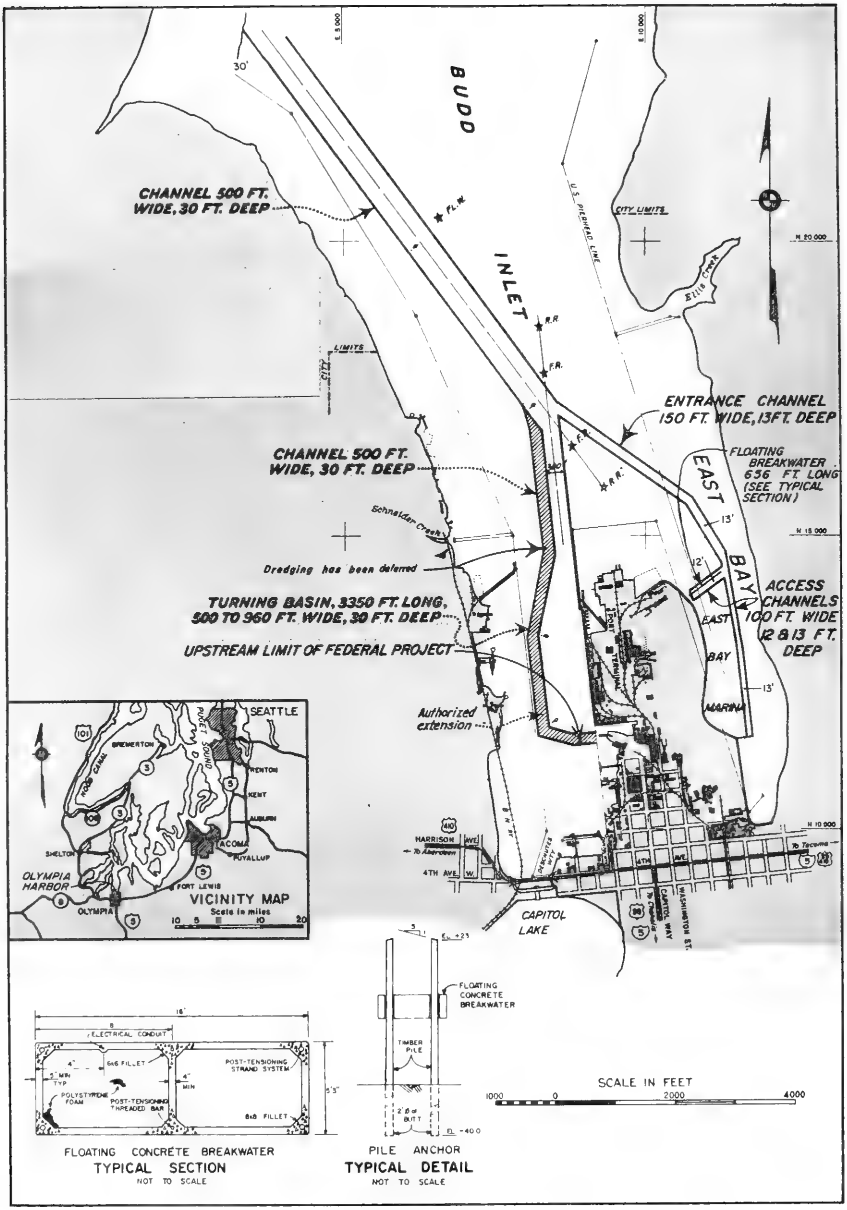

Figure 74. Site layout of Olympia Harbor, Washington (revised 1982)

Table 42

Port Angeles Harbor and Ediz Hook

Port Angeles, Washington

Date(s)	Construction and Rehabilitation History
1945	The project was authorized for expansion of the small-boat harbor and construction of the breakwaters.
1946	The breakwater was constructed of earth embankment core held in place by a two-step pile and plank bulkhead with the sides and slopes protected by rock. The top width of the earth embankment was about 100 ft; and the length of the breakwater was 750 ft.
1958	Plans for expansion of the boat basin and construction of the breakwaters were adopted.
1959	Port Angeles Harbor mooring basin was completed, including a 1,026-ft main breakwater and a 145-ft entrance breakwater, both of rock reinforced treated wood pile construction for a 5-ft design wave. The main breakwater was constructed to a top elevation of +17 ft mllw and left a 100-ft entrance gap between the main breakwater and an existing 750-ft long breakwater, with the gap protected by the entrance breakwater. The main breakwater was originally designed for rubble-mound construction, but it was modified to rock reinforced treated wood pile at the request of local interests to expedite the project.
1985	The harbor and cross section of the breakwater are illustrated in Figure 75. There are no records of needed repairs or rehabilitation.

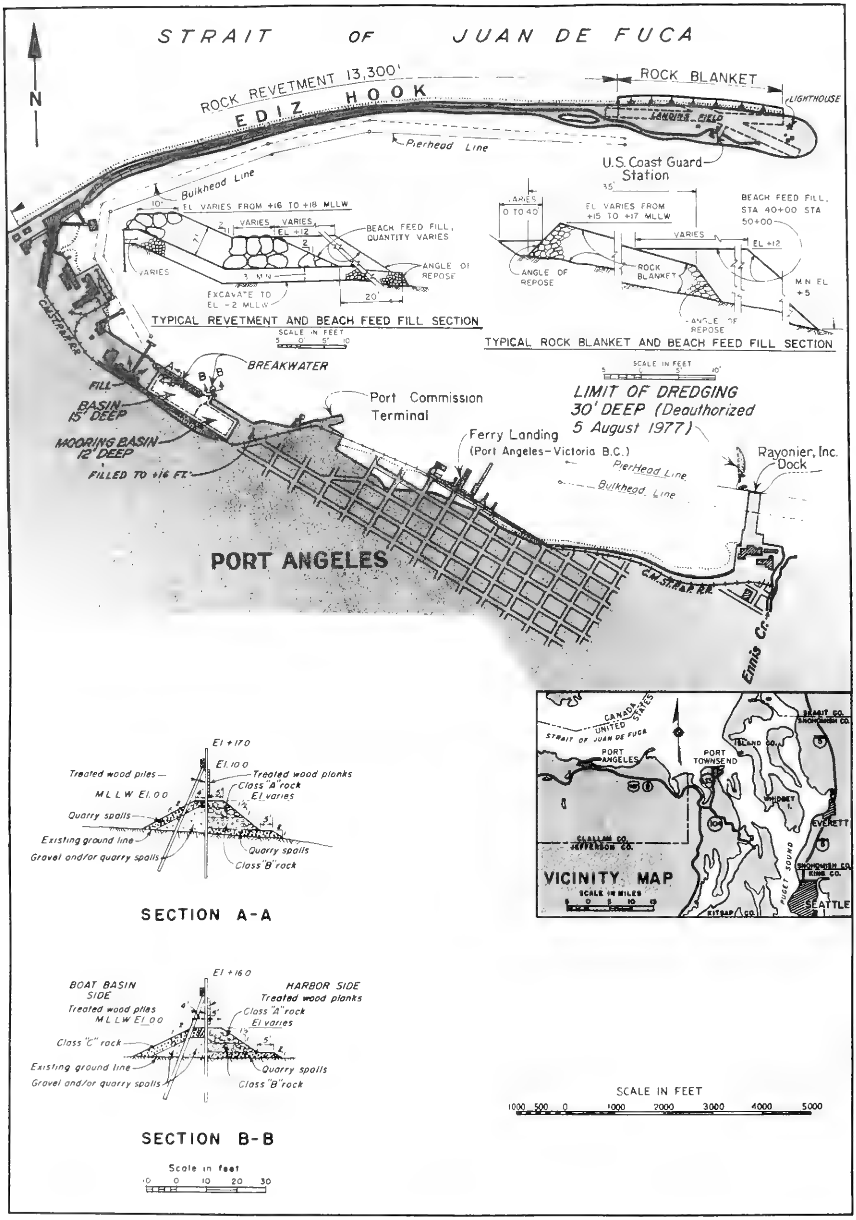

Figure 75. Site layout of Port Angeles, and Ediz Hook, Washington (revised 1979)

Table 43

Port Townsend Small-Boat Basin

Port Townsend, Washington

Date(s)	Construction and Rehabilitation History
1958	Improvements to the small-boat basin were authorized.
1962	The final design recommendations were submitted.
1964	Construction of 1,946 ft of the rubble-mound breakwater and dredging of the adjacent basin were completed. The breakwater was constructed to +18 ft mllw for a 5-ft design wave. An access channel was cut through the existing breakwater to -12 ft mllw with a width of 50 ft at the bottom of the gap and side slopes of 1:2.
1985	The harbor and cross section of the breakwater are illustrated in Figure 76. There are no records of needed repairs or rehabilitation.

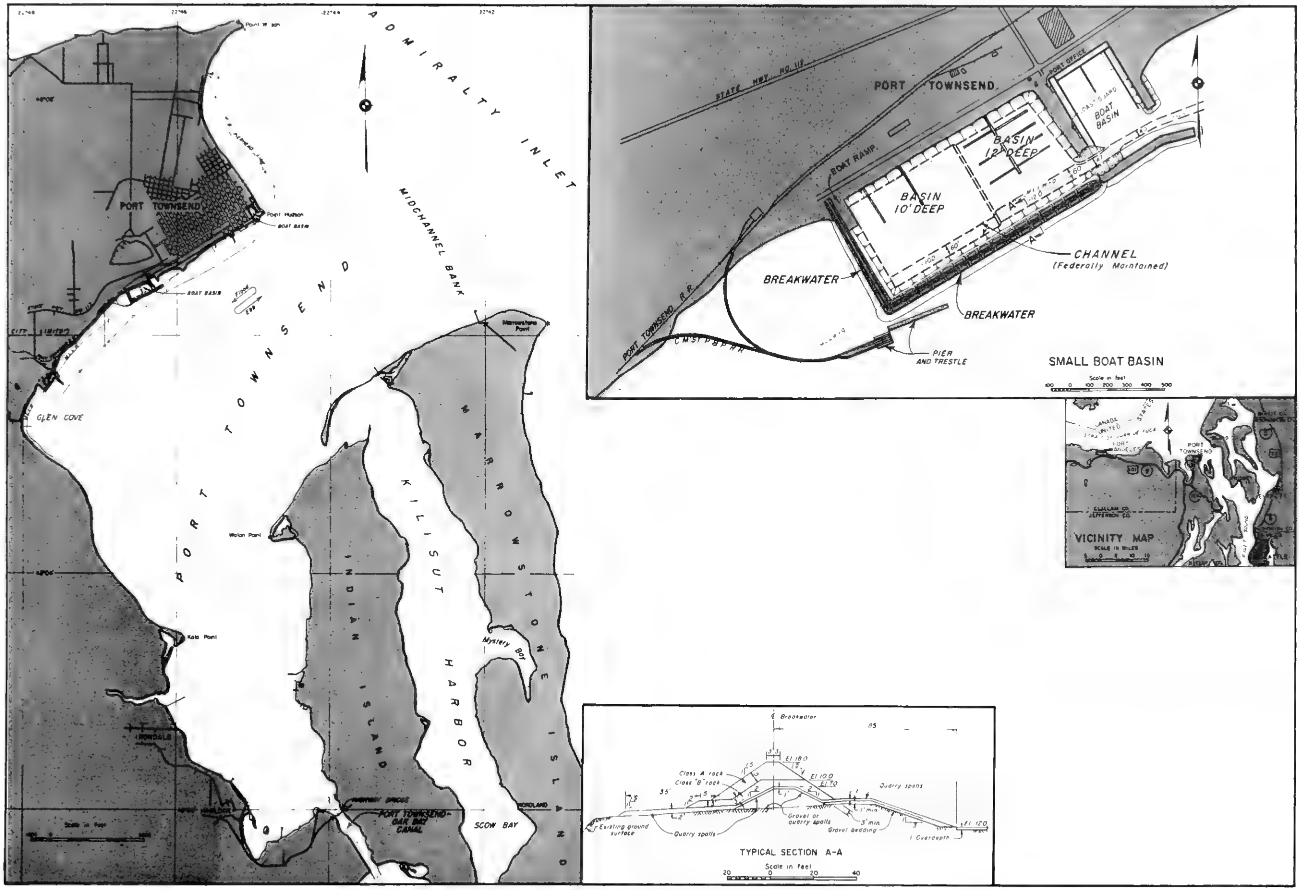

Figure 76. Site layout of Port Townsend, Washington (revised 1979)

Table 44

Quillayute River Boat Basin

La Push, Washington

Date(s)	Construction and Rehabilitation History
1929	Congress authorized a jetty and a dike at the river mouth. The spit was maintained by local interests.
1931	Jetty, dike, and bank revetment were constructed using 737 cu yd of rock for the dike and 17,226 tons of rock for the jetty.
1932	Storms damaged the jetty and the dike. Both were repaired and extended using 15,411 tons of rock.
1934	Settling was detected on the dike and jetty.
1939	Maintenance of the jetty and dike required 4,900 tons of rock.
1941	Repairs were made to the jetty and dike.
1950	The Corps recommended to Congress a deeper and longer channel and a raised jetty.
1954	Congress authorized a channel, a boat basin, and a raised jetty (to +15 ft mllw).
1955	The spit was breached in November.
1956	Port Angeles repaired the breach in the spit. The Corps dredged the channel, placing the dredge deposits on the spit, and assumed responsibility for repairing the spit. The spit was breached again in December, and the Corps performed emergency repairs.
1957	The boat basin was dredged, and a channel was dredged from the basin to Smith Slough. Dredged materials were deposited on the spit. The jetty was raised with 39,800 tons of rock, and emergency repairs were made on the dike with 2,000 cu yd of rock.
1959	The channel seaward of the basin was dredged.
1960	The jetty was raised and extended landward using 7,938 tons of rock.
1961	The jetty was repaired with 3,480 tons of rock.
1962	The timber training wall was built for the boat basin to help prevent shoaling, and the basin was dredged. In November, 135 ft of the recently completed training wall was undercut by the river and failed.

(Continued)

Table 44 (Concluded)

Date(s)	Construction and Rehabilitation History
1963	The timber training wall was rebuilt, and rock was placed at the foot of the training wall.
1968	Logs were cabled and buried in the spit.
1972	Gabions were placed along the south basin wall to prevent gravel washing over from the spit.
1973	Dredged material was much finer than previously. A rock blanket covering the spit was recommended with a life expectancy of 10 years.
1974	The rock blanket was installed using 50,000 tons of rock.
1978-1979	The rock blanket on the spit was replaced. The estimate of a 10-year life for the blanket was not met. The spit was breached during a storm in December 1979.
1979	The south jetty was repaired.
1980	Emergency repairs were made on the spit.
1985	The harbor and cross sections of the jetty are illustrated in Figure 77. The outer 250 ft of jetty was lowered to a point that the jetty was awash at high tides. Repair or rehabilitation is not anticipated in the near future.

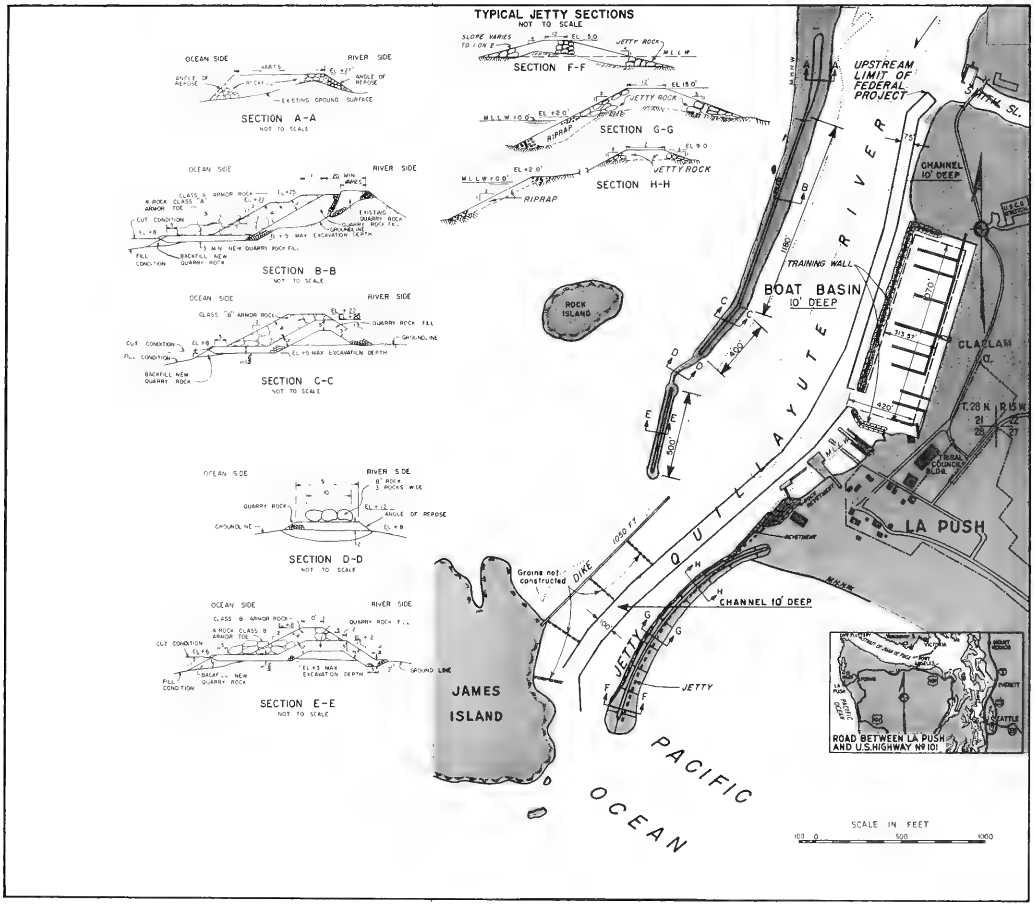

Figure 77. Site layout at Quillayute River, Washington (revised 1982)

Table 45

Shilshole Bay

Seattle, Washington

Date(s)	Construction and Rehabilitation History
1954	The project was adopted for the boat basin and a 4,200-ft breakwater.
1958	The breakwater was completed. The breakwater was constructed of dredged sand-fill between mounds of Class "C" rock which form the breakwater toes. Mounds were 7 ft above the ground line but not higher than -10 ft mllw to avoid disturbances during low tide periods during construction. A 3-ft-thick layer of gravel was placed over the dredged fill and used as a filter between the rock toes and the fill. Class "B" rock was placed over the Class "C" rock to a 1:1.5 finished slope, with a minimum thickness of 5 ft where it is exposed to wave action and 3 ft where it is covered by Class "A" rock. Class "A" armor rock weighing 1,500-3,000 lb was placed on the slopes to -10 ft mllw elevation. The breakwater crest was at +20 ft mllw; the breakwater was designed to withstand a 5-ft, 5-sec wave.
1961	A 240-ft-long rubble-mound extension was added to the existing breakwater.
1985	The harbor and cross sections of the breakwater are illustrated in Figure 78. There are no reports of needed repairs or rehabilitation.

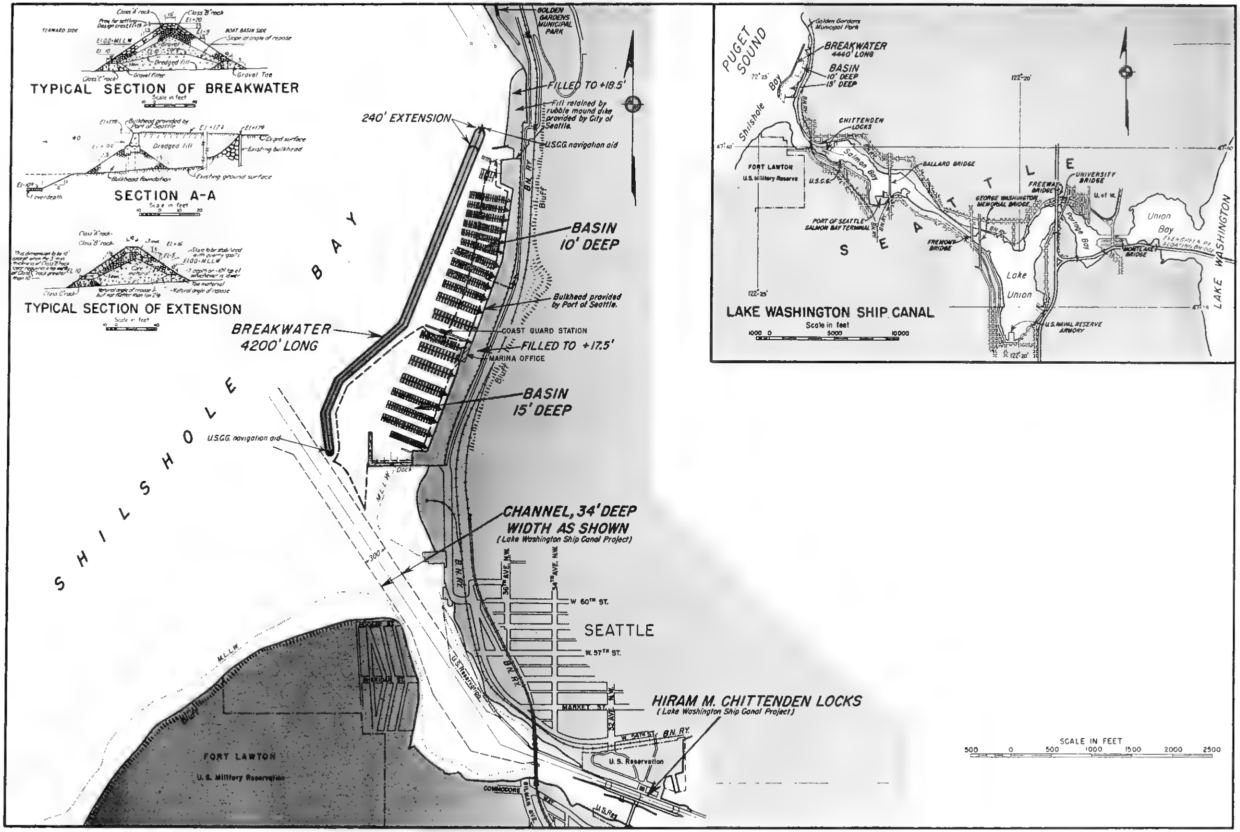

Figure 78. Site layout of Shilshole Bay, Washington (revised 1979)

Table 46

Swinomish Channel

Washington

Date(s)	Construction and Rehabilitation History
1892	The project was adopted.
1893	The north jetty was constructed. The jetty was extended west from "Hole in the Wall" to Saratoga Passage. The jetty was of rubble-mound and timber pile construction over brush mattresses with crest elevation of +8 ft mllw, crest width of 4 ft, and side slopes of 1:1. The timber piles were placed in a row along both sides of the crest with 6-ft center-to-center spacing.
1900	The north jetty was reconstructed.
1908	The south jetty, extending west from Goat Island into Saratoga Passage, was constructed of pile and rock. The jetty extended 3,650 ft to deep water with a crest elevation of +8 ft mllw. A 300-ft gap for fish and boat passage was left between Goat Island and the jetty.
1938	The Goat-McGlinn Island jetty was constructed of rubble mound over a 30-in.-thick layer of brush mattresses. The crest elevation was +15 ft mllw with a 3-ft crest width and 1:1 side slopes.
1941	The Goat-McGlinn Island jetty was reconstructed to a +15 ft mllw crest elevation with 5-ft crest width and 1:1 side slopes using 33,185 cu yd of stone. It was then repaired in September with 197 cu yd of stone and in October with 210 cu yd of stone.
1945-1946	The Goat-McGlinn jetty was rehabilitated with side slopes changed from 1:1 to 1:1.5, using 38,812 tons of rock.
1962	Navigation hazards at "Hole in the Wall" were removed.
1963	The Goat-McGlinn jetty was repaired using 16,408 tons of rock.
1973	Major rehabilitation and extension of south jetty were effected. The jetty had originally extended to deep water, but sediment deposits had enlarged the shallow shelf, and the jetty head was 1,000 ft from deep water at this time. The crest elevation of the jetty was +1 to +2 ft mllw, except for the outer 800 ft which was below mllw. The jetty was reconstructed of quarry spall and rock, 4,100 ft long, with crest elevation of +8 ft mllw, crest width of 8.5 ft, and side slopes of 1:1.5. Treated timber piles were placed on 200-ft centers on the Skagit Bay side to mark the structure, which would be submerged at high tide. Two gaps, each 50 ft wide, were left for fish passage, along with the existing 300-ft gap for fish and boat passage. A 3-pile dolphin was placed at each end of the jetty. Construction required 54,310 tons of rock.

(Continued)

Table 46 (Concluded)

Date(s)	Construction and Rehabilitation History
1985	The jetty layout and cross sections of the jetties are illustrated in Figure 79. The north jetty shows obvious deterioration, and the south jetty and Goat-McGlinn Island jetty appear in good condition.

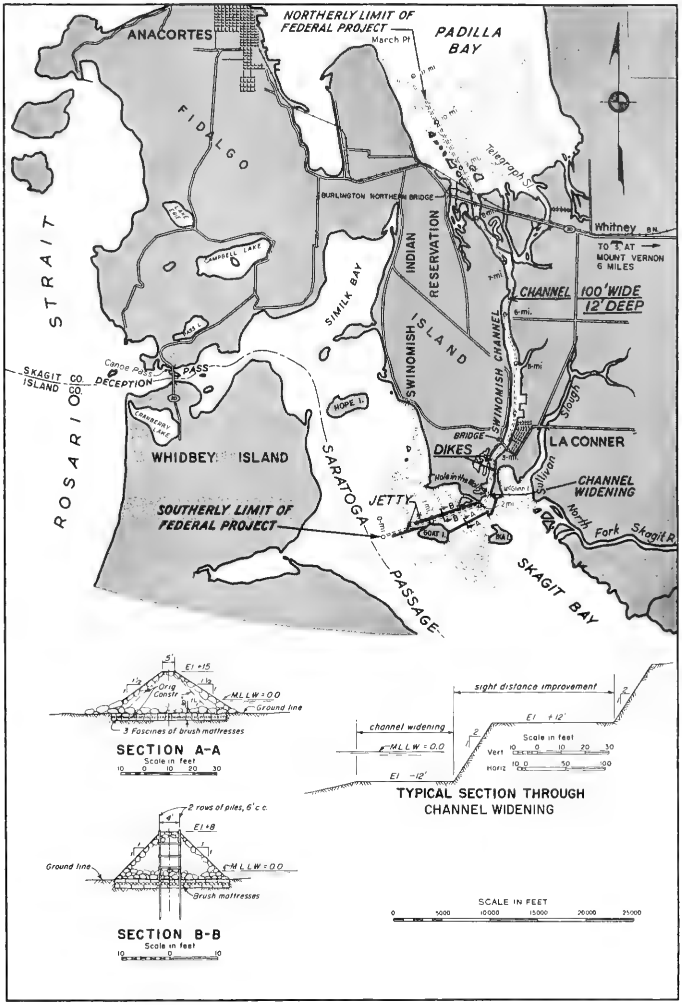

Figure 79. Site layout of Swinomish Channel, Washington (revised 1979)

Table 47

Waterway Connecting Port Townsend and Oak Bay

Port Townsend, Washington

Date(s)	Construction and Rehabilitation History
1913	The project was adopted.
1915-1916	The east jetty, west jetty, and bulkheads were constructed. The jetties were constructed of brush, pile, and stone with a 4-ft-wide crest and 1:1 side slopes. The west jetty was 550 ft long; the east jetty was 600 ft long. The bulkheads were constructed of brush, pile, and timber.
1925	The jetties and bulkheads were rehabilitated with 1,153 tons of rock.
1937	The rehabilitation work was performed on the east jetty by placing 393 tons of rock.
1961	The west jetty was rehabilitated with 12,173 tons of jetty rock to a crest elevation of +14 ft mllw, a crest width of 4 ft, and side slopes of 1:1.5.
1985	The jetty layout and cross sections are illustrated in Figure 80. There is no record of repairs or rehabilitation since 1961. The west jetty is in good condition. The east jetty shows some deterioration but is stable and functional.

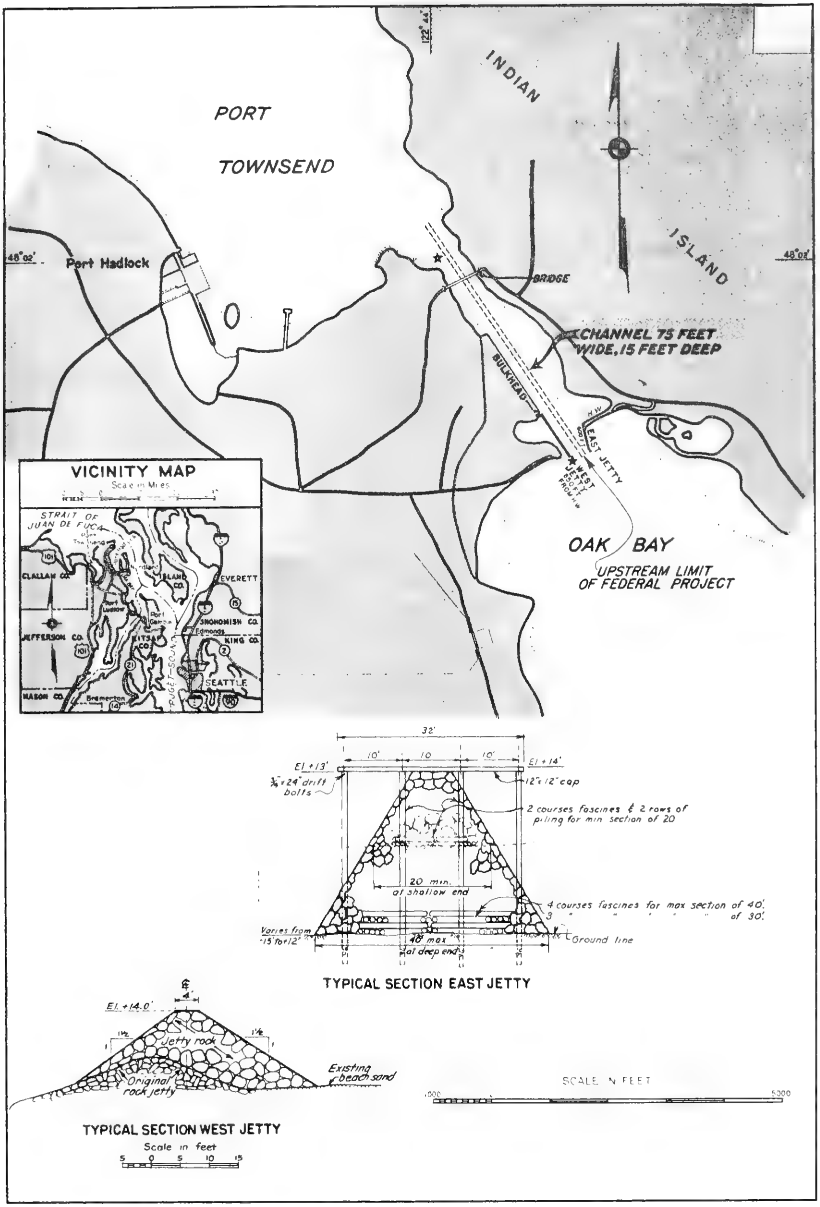

Figure 80. Site layout of waterway connecting Port Townsend and Oak Bay, Washington (revised 1979)

Table 48

Westhaven Cove Small-Boat Basin

West Port, Washington

Date(s)	Construction and Rehabilitation History
1929	The Port of Gray's Harbor dredged a small-boat basin in Westhaven Cove.
1935-1939	Reconstruction of the south jetty at Gray's Harbor blocked sand transport to Point Chehalis causing severe erosion.
1948	The project was adopted.
1950	West Port Marina breakwaters A and B were constructed of treated wood pilings with a top elevation of +17 ft mllw and a minimum penetration of 5 ft. Rock reinforcing was placed along the breakwater to an elevation of +4 ft mllw, with the crest extending 4 ft on each side. Creosoted 3- by 12-in. planking was placed along each side of the breakwater between elevations +4.5 and -0.5 ft mllw.
1953	Breakwater A was reinforced with rock and planks.
1954	Extension to the marina was recommended. Additional planks were installed on breakwater A.
1958	The Port of Gray's Harbor closed the opening between breakwaters A and B to lessen the effect of westerly swells entering the basin. The Corps constructed breakwater C with a design similar to that used in breakwaters A and B (1950), except that every twelfth pile was driven to a minimum penetration of 15 ft. A seven-pile dolphin was constructed at the harbor entrance end of the breakwater with a minimum penetration of 10 ft for each of the piles.
1959	Gaps of up to 4 in. between the pilings of breakwater C allowed an unacceptable level of wave energy to enter the basin. The breakwater was therefore modified by adding 3- by 12-in. planking between the top of the rock pile at +4.0 ft mllw and the bottom of the 10- by 12-in. wales at elevation +14.5 ft mllw.
1973	The closure breakwater was constructed.
1978	Further extensions to the marina were recommended.
1979	Extensions to the present design were completed. An existing 350-ft breakwater attached to breakwater C was removed, an 865-ft extension to breakwater C was constructed, and a 200-ft stub breakwater was constructed. The extension to breakwater C was constructed of timber pile with a rock toe, with a 200-ft rubble-mound section to reduce wave reflection back to a commercial pier. Crest elevation was +17 ft mllw.

(Continued)

Table 48 (Concluded)

Date(s)	Construction and Rehabilitation History
1983	A detached breakwater at the southerly end of the basin was damaged by a storm. Some rock was displaced, and the decayed planking was damaged.
1984	The damaged breakwater was repaired.
1985	The basin layout and cross sections of the breakwaters are illustrated in Figure 81. Breakwaters are in reasonably good repair and appear to be functioning properly.

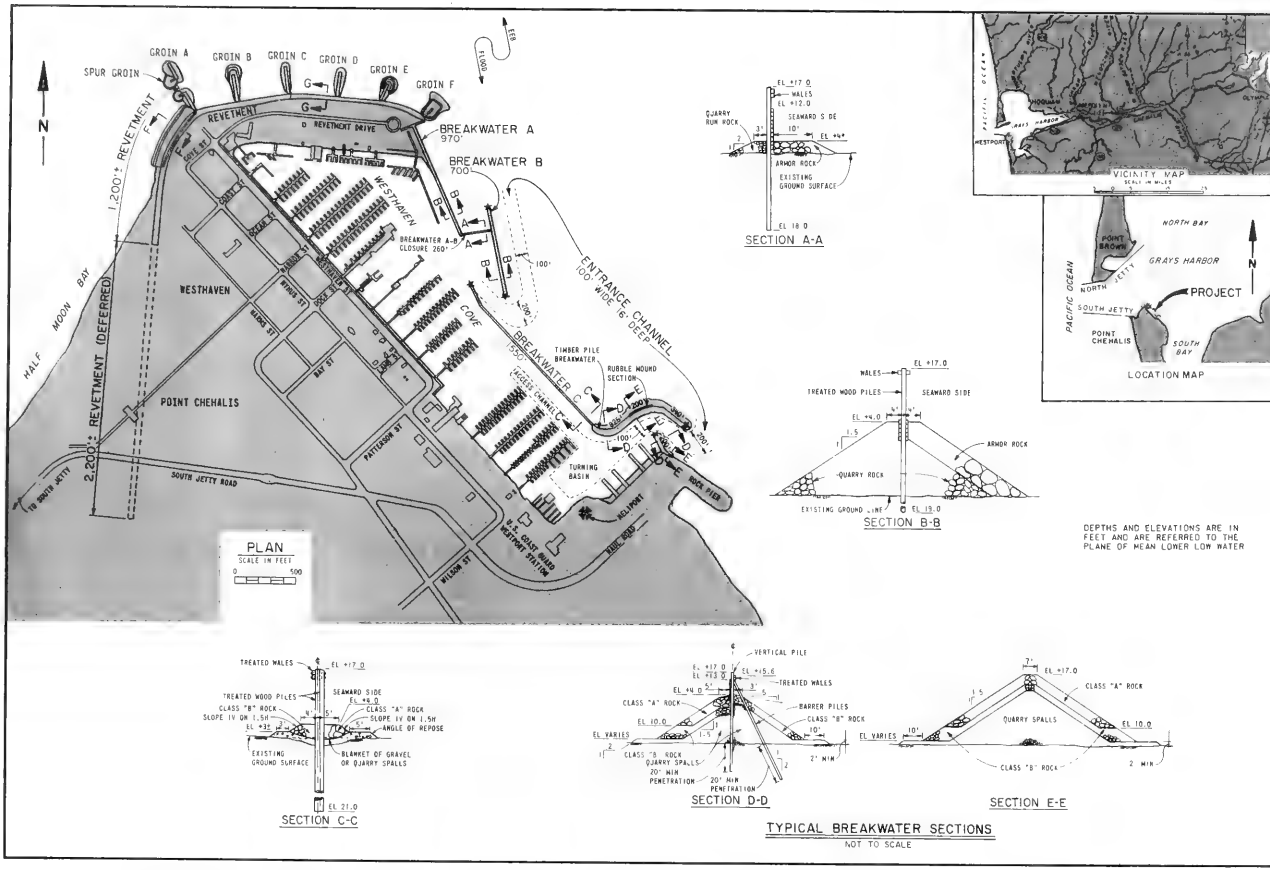

Figure 81. Site layout of Westhaven Cove Small-Boat Basin, Washington (revised 1979)

Table 49

Willapa River and Harbor and Naselle River

Willapa Bay, Washington

Date(s)	Construction and Rehabilitation History
1916	Willapa River and Harbor project adopted.
1954	The Willapa River and Harbor project was modified to include the mooring basin and the breakwater at Nahcotta.
1957	The breakwater design at Nahcotta was modified to conform to requests by local interests.
1957-1958	The Nahcotta breakwater was constructed. The 1,500-ft-long breakwater was of rubble-mound construction, with the crest at elevation +15 ft mllw, width of 6 ft, and side slopes of 1:1.5. The landward end tied into an existing oystershell mound at the landward end of Nahcotta Wharf. A 2-ft-thick layer of quarry spalls was extended 15 ft from the seaward toe on the channel side of the breakwater to protect against toe scour. The breakwater required 43,700 tons of rock to complete.
1958	The Nahcotta mooring basin and channels were dredged.
1985	The harbor layout and breakwater cross sections are illustrated in Figure 82. There are no reports of needed repairs or rehabilitation for the breakwater.

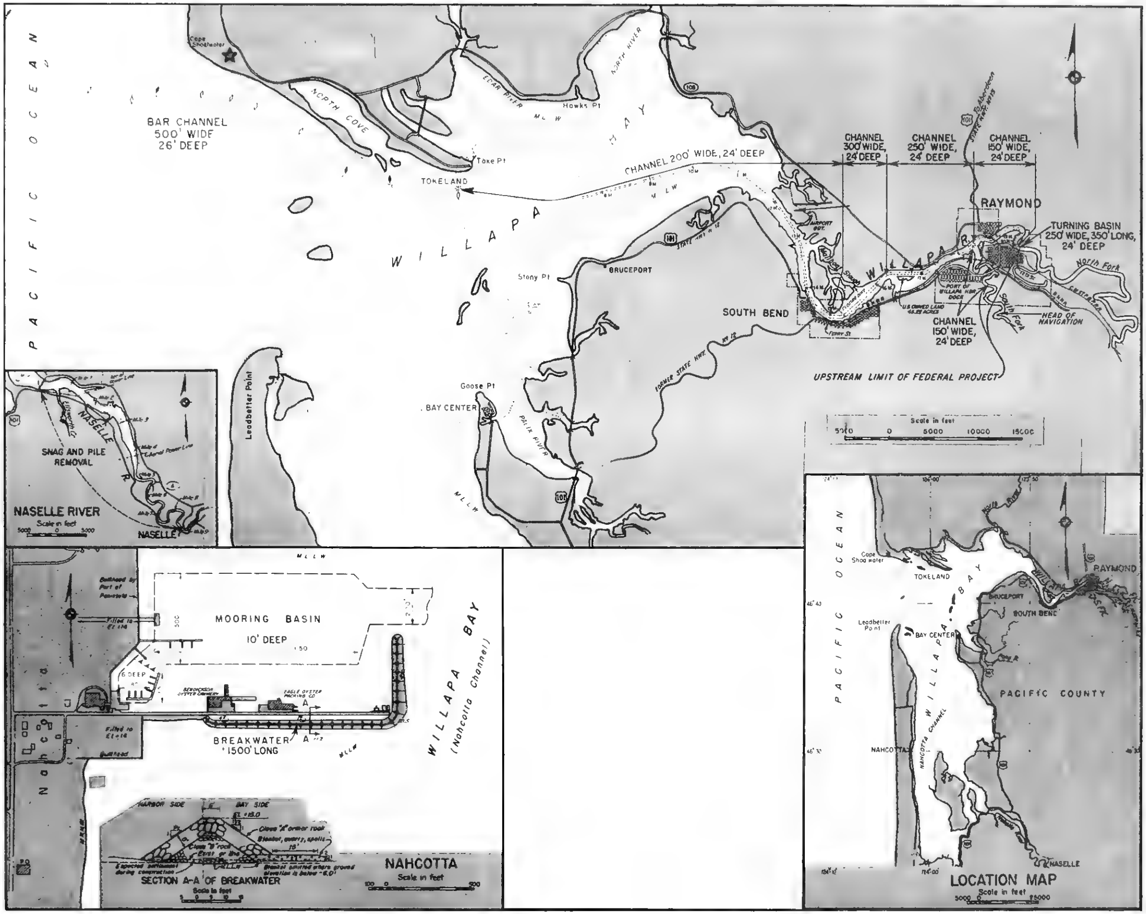

Figure 82. Site layout of Willapa River and Harbor and Naselle River, Washington (revised 1979)